# THE ROSETTA STONE

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**IDEAS THAT HAVE INFLUENCED CIVILIZATION, IN THE ORIGINAL DOCUMENTS, TRANSLATED**

Joseph

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**INDEXES**



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# ILLUSTRATIONS

## VOLUME X

# TABLE OF CONTENTS

## VOLUME X.

5

# SOCIAL MOVEMENTS

PROBABLY the most important social movement of the present time springs from a conception of the state as a social organism in opposition to the Adam Smith conception of it as economically merely a conglomeration of individuals. On the latter theory each individual should be left to himself, competition should be uncontrolled, the government should keep out of economic affairs. On the former basis, the state is an organism which should control all its parts for the good of the whole.

Such attempts by government to control trade are not new, but the object would seldom be "for the good of the whole" except where was acknowledged the sovereignty of the people. It is interesting to glance back over such attempts to control industry made by governments, and at the same time compare the efforts made by individuals or classes to control it for their own benefit.

In Greece, Sparta by its peculiar laws made itself an agricultural aristocracy with the work done by serfs. Trade was practically annihilated. In Athens all were free to come and trade. The government, however, fixed a maximum price on olives, grain, barley meal, bread; saw that the food was kept pure, and the measures correct; and prevented a "corner" on grain by compelling two-thirds of that imported to be put on the market. Here, too, as in Sparta, the traders were foreigners and not a respected class. The manual work was done by slaves.

In Italy the land fell into the hands of large slave-holders, who used it for grazing purposes. The government sold imported grain for less than the small Italian farmers could raise it, and thus ruined the

small farmer for the benefit of the population at Rome. The Roman senator was forbidden from entering into any speculative trade venture, *e. g.*, commerce, or the farming of the revenue; but this law was often avoided by joining an association. Almost all large businesses at Rome were carried on by incorporated associations. A man was advised to send out fifty ships with forty-nine other merchants rather than to send out one on his own account. It gave him the benefit of the law of averages,—acted as now does insurance, which was unknown in those days.

Hand labor suffered in social status because of the proximity of slave labor. But this seems to have been lessened to some extent by the existence of trade corporations. Numa is fabled to have divided workmen into nine classes, each of which became a society. Such associations later became regular corporations, and exerted considerable influence on the economics of the time. The membership seems both in the time of the republic and empire to have been voluntary, but they seem to have included practically all free craftsmen in the large cities.

Taken altogether the system of the empire was decidedly paternal. Mines and roads of communication were owned by the government, and the emperor paid very close attention to affairs which we should now consider strictly municipal.

During the middle ages, practically all trades were under control of trade guilds. We read of a weavers' and fullers' guild in England as early as 1130. No one was permitted by the king to follow an occupation unless a member of the guild, and an apprenticeship, usually of seven years, was necessary before a man could be admitted to a guild. Merchant guilds also existed early, but liberty in buying and selling was in general given to all in England in 1335. From the twelfth to the eighteenth century the guilds practically regulated industry, subject to the control of the king. In the eighteenth century the guilds did not keep pace with the growth of the great industries, and were fiercely attacked by the *laissez-faire* school of economists. Their influence waned and the laws in their favor were left uninforced. The law compelling apprenticeship was abolished in 1814, and all trade privileges of the guilds taken away. But not long after this trade unions began to be developed to take their place.

Even before the time of the Tudors it was the custom of the king to give the monopoly of dealing in a certain article to some favorite as a reward. In the time of Elizabeth these monopolies included such

things as salt, currants, iron, playing cards, carriage of leather, ashes, coals, bottles, vinegar, etc. The growth of the system roused great discontent, a fierce struggle was waged against it in Parliament in 1601, and Elizabeth promised to revoke the patents. The matter was again brought to a crisis under James I. by the extortion of the licensers of inns, and the whole power was taken from the Crown except in the case of patent rights. During the next century Parliament gave exclusive power to trade in some certain district to a particular company formed for exploitation or colonization, as, for example, the East India Company or the many American companies, but the economic ideas of Adam Smith at the end of the eighteenth century overthrew even this policy, and since then the government has confined exclusive privileges given to private individuals to patents or copyrights.

Nineteenth century socialism came in with the century. Fourier in 1808 published his theoretical pantheistic view of the world and maintained that all civilization had been but putting the world farther from its Creator. His phantasies passed without effect, but in 1817 Owen laid a scheme for a socialistic community before the House of Commons committee on the poor law. A number of such social communities sprang up, among them the famous Brook Farm in the United States, but practically all were short lived.

In 1831 the workingmen of Lyons, France, rose in revolt under a banner inscribed "Live working or die fighting." A like movement was the Chartist revolts by workingmen in the thirties, for although their demands were political, yet the ground of the discontent was primarily economic. All of these movements had their rise and fall leaving little permanent results except the establishment of trade unions, but showing an important undercurrent in society, when Karl Marx gave a scientific expression to the movement in Germany.

Karl Marx (1818-1883) was of Jewish descent. He was a lawyer, but gave up his profession for social studies. Between 1843 and 1845 he was in Paris, and published several articles on socialism. At this time, also, he met his lifelong friend, Friedrich Engels. In 1845 he was expelled from Paris and settled in Brussels. A society of socialists had been organized as the Communist League and at a congress held in 1847, Marx and Engels gave to the world the famous "Manifesto of the Communist Party" included below.

In 1867 Marx published the first volume of his great work "Das Kapital." The basis of his system is Locke's idea that the source of

value and property is labor. Hence he argues that all surplus product over the necessary subsistence of the laborer belongs to the laborer, but he declares that as a fact this goes to the capitalist.

This theory found an important result in the formation of The International, a league of workmen of the continent which lasted from 1864 to 1872, and in the gradual growth of trade unions.

One of the first organizers of modern trade unions in Germany was Ferdinand Lassalle, but at his death in 1864 his general workingmen's union numbered only 4,610 members.

In a great congress at Eisenach in 1869 representatives of the many outside unions founded the social democratic workingmen's party and a combination was made with the Lassalle party in 1875. The two together by this time numbered 25,000 members. Since this time the socialists have been an important power in German politics.

In England from 1799 to 1824 there had grown up a mass of laws against restriction of trade, as a reaction against the mercantile theory of the eighteenth century. Until 1824 it was a crime to belong to a union. Such restrictions were partly removed in that year and more fully in 1871.

In the United States there were many local unions early in the century, but the first union including all the main trades of a city seems to have been in 1833 in New York. In 1861 a number of trades had a national organization. After the war organization was again begun and spread rapidly until the panic of '73. From 1877 to 1893 the labor unions seem to have had a rapid growth and the decrease in the panic of '93 was only about 12 per cent., not as great as during previous depressions. To-day practically all general trades are well organized, especially in cities of some size.

During the past generation there has been a constant and growing demand for changes in our system of municipal government. Numerous investigations and disclosures have brought out the weaknesses and faults of the present plan as administered under partisan politics and have shown the great need of efficiency. To this end, many systems have been devised and applied in all parts of the country and many states have made provisions dealing with the problem. The State of Ohio, for example, has recently enacted a law which permits the citizens of any municipality to decide for themselves which form of gov-

ernment they shall adopt. This law provides for the adoption of the Commission Plan, the City Manager Plan, and the Federal Plan.

Political economists agree that the problem of levying taxes in such a way as to equally distribute the burden of government, is a difficult one. Henry George, in the Single Tax, claims to have given the world a new theory in taxation which will not only accomplish the difficult end, but provide, at the same time, a remedy for the problems between labor and capital, the question of wage, interest, profit, and even the moral welfare of the people.

The modern theory of rural credits and cooperation was conceived and brought to its highest development in Europe. Nearly every European country has some efficient system of agricultural cooperation and credits which have been a factor in the national progress and development. The reports of Messrs. Wm. M. Brown and John Cunningham, members of the American Commission which investigated the systems employed in practically all the European countries, will be of benefit and interest to the people of the United States who are desirous of the development of greater efficiency in agriculture.

# KARL MARX

KARL MARX was born of Jewish parents at Treves, in the province of the Rhine, May 5, 1818. He studied at Bonn and Berlin, and began the practice of law, then gave it up, and became editor of a radical newspaper that was suppressed because of its attacks on the Prussian government.

He moved to Paris, but was expelled in 1845, and went to Brussels, where he founded a German workingman's association, and issued (with Engels) his famous "Manifesto" given below.

He again became editor of the *Rheinische Zeitung* at Cologne, but it was again suppressed, and he went to England, where were his headquarters for the rest of his life.

The International Workingmen's Association was founded in 1864. The first volume of *Das Kapital* was issued in 1867. Marx starts in with Locke's idea that the basis of property is labor, and works out a theory that in the evolution of society, the employing class has come to appropriate the surplus earnings of labor. This, with his consideration of society as an evolution, are the two most important and influential ideas of the book.

The "Manifesto" was much more radical and heated than this later exposition of his ideas, but he believes in the inevitable assumption by the laboring class of the means of production.

His theories are a part of almost all socialistic writings, and, without his radical and unnecessary features, the idea that society is an organism which should control what concerns all for the good of all is playing a prominent part in all present day social thought.

Marx died in London, March 14, 1883.

# KARL MARX

# MANIFESTO OF THE COMMUNIST PARTY

By Karl Marx and Friedrich Engels

A specter is haunting Europe—the specter of Communism. All the powers of old Europe have entered into a holy alliance to exorcise this specter; Pope and Czar, Metternich and Guizot, French radicals and German police spies.

Where is the party in opposition that has not been decried as communistic by its opponents in power? Where the opposition that has not hurled back the branding reproach of Communism, against the more advanced opposition parties, as well as against its reactionary adversaries?

Two things result from this fact.

I. Communism is already acknowledged by all European powers to be in itself a power.

II. It is high time that Communists should openly, in the face of the whole world, publish their views, their aims, their tendencies, and meet this nursery tale of the Specter of Communism with a manifesto of the party itself.

To this end the Communists of various nationalities have assembled in London, and sketched the following manifesto to be published in the English, French, German, Italian, Flemish and Danish languages.

## I.

### Bourgeois and Proletarians

The history of all hitherto existing society is the history of class struggles.

Freeman and slave, patrician and plebian, lord and serf, guild-master and journeyman, in a word, oppressor and oppressed, stood in constant opposition to one another, carried on an uninterrupted, now hidden, now open fight, that each time ended either in revolutionary reconstitution of society at large, or in the common ruin of the contending classes.

In the earlier epochs of history we find almost everywhere a complicated arrangement of society into various orders, a manifold grada-

tion of social rank. In ancient Rome we have patricians, knights, plebeians, slaves; in the middle ages, feudal lords, vassals, guild-masters, journeymen, apprentices, serfs; in almost all of these classes, again, subordinate gradations.

The modern bourgeois society that has sprouted from the ruins of feudal society has not done away with class antagonisms. It has but established new classes, new conditions of oppression, new forms of struggle in place of the old ones.

Our epoch, the epoch of the bourgeois, possesses, however, this distinctive feature: it has simplified the class antagonisms. Society as a whole is more and more splitting up into two great hostile camps, into two great classes directly facing each other: Bourgeoisie and Proletariat.

From the serfs of the middle ages sprang the chartered burghers of the earliest towns. From these burgesses the first elements of the bourgeoisie were developed.

The discovery of America, the rounding of the Cape, opened up fresh ground for the rising bourgeoisie. The East Indian and Chinese markets, the colonization of America, trade with the colonies, the increase in the means of exchange and in commodities generally, gave to commerce, to navigation, to industry, an impulse never before known, and thereby, to the revolutionary element in the tottering feudal society, a rapid development.

The feudal system of industry, under which industrial production was monopolized by close guilds, now no longer sufficed for the growing wants of the new markets. The manufacturing system took its place. The guild masters were pushed on one side by the manufacturing middle class; division of labor between the different corporate guilds vanished in the face of division of labor in each single workshop.

Meantime the markets kept ever growing, the demand ever rising. Even manufacture no longer sufficed. Thereupon steam and machinery revolutionized industrial production. The place of manufacture was taken by the giant, Modern Industry, the place of the industrial middle class, by industrial millionaires, the leaders of the whole industrial armies, the modern bourgeois.

Modern industry has established the world's market, for which the discovery of America paved the way. The market has given an immense development to commerce, to navigation, to communication by land. This development has, in its turn, reacted on the extension of industry; and in proportion as industry, commerce, navigation and rail-

ways extended, in the same proportion the bourgeoisie developed, increased its capital, and pushed into the background every class handed down from the middle ages.

We see, therefore, how the modern bourgeoisie is itself the product of a long course of development, of a series of revolutions in the modes of production and of exchange.

Each step in the development of the bourgeoisie was accompanied by a corresponding political advance of that class. An oppressed class under the sway of the feudal nobility, an armed and self-governing association in the mediæval commune, here independent urban republic (as in Italy and Germany), there taxable "third estate" of the monarchy (as in France), afterwards, in the period of manufacture proper, serving either the semi-feudal or the absolute monarchy as a counterpoise against the nobility, and, in fact, corner-stone of the great monarchies in general, the bourgeoisie has at last, since the establishment of Modern Industry and of the world's market, conquered for itself, in the modern representative State, exclusive political sway. The executive of the modern State is but a committee for managing the common affairs of the whole bourgeoisie.

The bourgeoisie, historically, has played a most revolutionary part.

The bourgeoisie, wherever it has got the upper hand, has put an end to all feudal, patriarchal, idyllic relations. It has pitilessly torn asunder the motley feudal ties that bound man to his "natural superiors," and has left remaining no other nexus between man and man than naked self-interest, callous "cash payment." It has drowned the most heavenly ecstacies of religious fervor, of chivalrous enthusiasm, of philistine sentimentalism, in the icy water of egotistical calculation. It has resolved personal worth into exchange value, and in place of the numberless indefeasible chartered freedoms, has set up that single, unconscionable freedom—Free Trade. In one word, for exploitation, veiled by religious and political illusions, it has substituted naked, shameless, direct, brutal exploitation.

The bourgeoisie has stripped of its halo every occupation hitherto honored and looked up to with reverent awe. It has converted the physician, the lawyer, the priest, the poet, the man of science, into its paid wage laborers.

The bourgeoisie has torn away from the family its sentimental veil, and has reduced the family relation to a mere money relation.

The bourgeoisie has disclosed how it came to pass that the brutal

display of vigor in the middle ages, which Reactionists so much admire, found its fitting complement in the most slothful indolence. It has been the first to show what man's activity can bring about. It has accomplished wonders far surpassing Egyptian pyramids, Roman aqueducts, and Gothic cathedrals; it has conducted expeditions that put in the shade all former exoduses of nations and crusades.

The bourgeoisie cannot exist without constantly revolutionizing the instruments of production, and thereby the relations of production, and with them the whole relations of society. Conservation of the old modes of production in unaltered forms was, on the contrary, the first condition of existence for all earlier industrial classes. Constant revolutionizing of production, uninterrupted disturbance of all social conditions, everlasting uncertainty and agitation, distinguish the bourgeois epoch from all earlier ones. All fixed, fast-frozen relations, with their train of ancient and venerable prejudices and opinions, are swept away; all new-formed ones become antiquated before they can ossify. All that is solid melts into air, all that is holy is profaned, and man is at last compelled to face with sober senses his real conditions of life and his relations with his kind.

The need of a constantly expanding market for its products chases the bourgeoisie over the whole surface of the globe. It must nestle everywhere, settle everywhere, establish connections everywhere.

The bourgeoisie has through its exploitation of the world's market given a cosmopolitan character to production and consumption in every country. To the great chagrin of Reactionists, it has drawn from under the feet of industry the national ground on which it stood. All old-established national industries have been destroyed or are daily being destroyed. They are dislodged by new industries, whose introduction becomes a life and death question for all civilized nations, by industries that no longer work up indigenous raw material, but raw material drawn from the remotest zones, industries whose products are consumed, not only at home, but in every quarter of the globe. In place of the old wants, satisfied by the productions of the country, we find new wants, requiring for their satisfaction the products of distant lands and climes. In place of the old local and national seclusion and self-sufficiency, we have intercourse in every direction, universal inter-dependence of nations. And as in material, so also in intellectual production. The intellectual creations of individual nations become common property. National one-sidedness and narrow-mindedness become more and

more impossible, and from the numerous national and local literatures, there arises a world literature.

The bourgeoisie, by the rapid improvement of all instruments of production, by the immensely facilitated means of communication, draws all, even the most barbarian, nations into civilization. The cheap prices of its commodities are the heavy artillery with which it batters down all Chinese walls, with which it forces the barbarians' intensely obstinate hatred of foreigners to capitulate. It compels all nations, on pain of extinction, to adopt the bourgeois mode of production; it compels them to introduce what it calls civilization into their midst, *i. e.*, to become bourgeois themselves. In one word, it creates a world after its own image.

The bourgeoisie has subjected the country to the rule of the towns. It has created enormous cities, has greatly increased the urban population as compared with the rural, and has thus rescued a considerable part of the population from the idiocy of rural life. Just as it has made the country dependent on the towns, so has it made barbarian and semi-barbarian countries dependent on the civilized ones, nations of peasants on nations of bourgeois, the East on the West.

The bourgeoisie keeps more and more doing away with the scattered state of the population, of the means of production, and of property. It has agglomerated population, centralized means of production, and has concentrated property in a few hands. The necessary consequence of this was political centralization. Independent, or but loosely connected provinces, with separate interests, laws, governments and systems of taxation, became lumped together into one nation, with one government, one code of laws, one national class interest, one frontier, and one customs tariff.

The bourgeoisie, during its rule of scarce one hundred years, has created more massive and more colossal productive forces than have all preceding generations together. Subjection of Nature's forces to man, machinery, application of chemistry to industry and agriculture, steam navigation, railways, electric telegraphs, clearing of whole continents for cultivation, canalization of rivers, whole populations conjured out of the ground—what earlier century had even a presentiment that such productive forces slumbered in the lap of social labor?

We see then: the means of production and of exchange on whose foundation the bourgeoisie built itself up, were generated in feudal society. At a certain stage in the development of these means of pro-

duction and of exchange, the conditions under which feudal society produced and exchanged, the feudal organization of agriculture and manufacturing industry, in one word, the feudal relations of property, became no longer compatible with the already developed productive forces; they became so many fetters. They had to be burst asunder.

Into their place stepped free competition, accompanied by a social and political constitution adapted to it, and by the economical and political sway of the bourgeois class.

A similar movement is going on before our own eyes. Modern bourgeois society with its relations of production, of exchange, and of property, a society that has conjured up such gigantic means of production and of exchange, is like the sorcerer, who is no longer able to control the powers of the nether world whom he has called up by his spells. For many a decade past the history of industry and commerce is but the history of the revolt of modern productive forces against modern conditions of production, against the property relations that are the conditions for the existence of the bourgeoisie and of its rule. It is enough to mention the commercial crises that by their periodical return put on its trial, each time more threateningly, the existence of the bourgeois society. In these crises a great part not only of the existing products, but also of the previously created productive forces, is periodically destroyed. In these crises there breaks out an epidemic that, in all earlier epochs, would have seemed an absurdity—the epidemic of overproduction. Society suddenly finds itself put back into a state of momentary barbarism; it appears as if a famine, a universal war of devastation had cut off the supply of every means of subsistence; industry and commerce seem to be destroyed; and why? because there is too much civilization, too much means of subsistence, too much industry, too much commerce. The productive forces at the disposal of society no longer tend to further the development of the conditions of bourgeois property; on the contrary, they have become too powerful for these conditions, by which they are fettered, and so soon as they overcome these fetters, they bring disorder into the whole of bourgeois society, endanger the existence of bourgeois property. The conditions of bourgeois society are too narrow to comprise the wealth created by them. And how does the bourgeoisie get over these crises? On the one hand, by enforced destruction of a mass of productive forces; on the other, by the conquest of new markets, and by the more thorough exploitation of the old ones. That is to say, by paving the way for more

extensive and more destructive crises, and by diminishing the means whereby crises are prevented.

The weapons with which the bourgeoisie felled feudalism to the ground are now turned against the bourgeoisie itself.

But not only has the bourgeoisie forged the weapons that bring death to itself; it has also called into existence the men who are to wield those weapons—the modern working class—the proletarians.

In proportion as the bourgeoisie, *i. e.,* capital, is developed, in the same proportion is the proletariat, the modern working class, developed; a class of laborers who live only so long as they find work, and who find work only so long as their labor increases capital,—These laborers, who must sell themselves piecemeal, are a commodity. like every other article of commerce, and are consequently exposed to all the vicissitudes of competition, to all the fluctuations of the market.

Owing to the extensive use of machinery and to division of labor, the work of the proletarians has lost all individual character, and, consequently, all charm for the workman. He becomes an appendage of the machine, and it is only the most simple, most monotonous, and most easily acquired knack, that is required of him. Hence, the cost of production of a workman is restricted almost entirely to the means of subsistence that he requires for his maintenance, and for the propagation of his race. But the price of a commodity, and therefore also of labor, is equal to its cost of production. In proportion, therefore, as the repulsiveness of the work increases, the wage decreases. Nay, more, in proportion as the use of machinery and division of labor increases, in the same proportion the burden of toil also increases, whether by prolongation of the working hours, by increase of the work exacted in a given time, or by increased speed of the machinery, etc.

Modern industry has converted the little workshop of the patriarchal master into the great factory of the industrial capitalist. Masses of laborers, crowded into the factory, are organized like soldiers. As privates of the industrial army they are placed under the command of a perfect hierarchy of officers and sergeants. Not only are they slaves of the bourgeois class, and of the bourgeois State, they are daily and hourly enslaved by the machine, by the overlooker, and, above all, by the individual bourgeois manufacturer himself. The more openly this despotism proclaims gain to be its end and aim, the more petty, the more hateful and the more embittering it is.

The less skill and exertion of strength is implied in manual labor.

in other words, the more modern industry becomes developed, the more is the labor of men superseded by that of women. Differences of age and sex have no longer any distinctive social validity for the working class. All are instruments of labor, more or less expensive to use, according to age and sex.

No sooner is the exploitation of the laborer by the manufacturer so far at an end that he receives his wages in cash, than he is set upon by the other portions of the bourgeoisie, the landlord, the shopkeeper, the pawnbroker, etc.

The lower strata of the middle class—the small tradespeople, shopkeepers, and retired tradesmen generally, the handicraftsmen and peasants—all these sink gradually into the proletariat, partly because their diminutive capital does not suffice for the scale on which modern industry is carried on, and is swamped in the competition with the large capitalists, partly because their specialized skill is rendered worthless by new methods of production. Thus the proletariat is recruited from all classes of the population.

The proletariat goes through various stages of development. With its birth begins its struggle with the bourgeoisie. At first the contest is carried on by individual laborers, then by the workpeople of a factory, then by the operatives of one trade, in one locality, against the individual bourgeois who directly exploits them. They direct their attacks not against the bourgeois conditions of production, but against the instruments of production themselves; they destroy imported wares that compete with their labor, they smash to pieces machinery, they set factories ablaze, they seek to restore by force the vanished status of the workman of the middle ages.

At this stage the laborers still form an incoherent mass scattered over the whole country, and broken up by their mutual competition. If anywhere they unite to form more compact bodies, this is not yet the consequence of their own active union, but of the union of the bourgeoisie, which class, in order to attain its own political ends, is compelled to set the whole proletariat in motion, and is moreover yet, for a time, able to do so. At this stage, therefore, the proletarians do not fight their enemies, but the enemies of their enemies, the remnants of absolute monarchy, the land owners, the non-industrial bourgeois, the petty bourgeoisie. Thus the whole historical movement is concentrated in the hands of the bourgeoisie; every victory so obtained is a victory for the bourgeoisie.

But with the development of industry the proletariat not only increases in number; it becomes concentrated in greater masses, its strength grows and it feels that strength more. The various interests and conditions of life within the ranks of the proletariat are more and more equalized, in proportion as machinery obliterates all distinctions of labor, and nearly everywhere reduces wages to the same low level. The growing competition among the bourgeois, and the resulting commercial crises, make the wages of the workers ever more fluctuating. The unceasing improvement of machinery, ever more rapidly developing, makes their livelihood more and more precarious; the collisions between individual workmen and individual bourgeois take more and more the character of collisions between two classes. Thereupon the workers begin to form combinations (Trades' Unions) against the bourgeois; they club together in order to keep up the rate of wages; they found permanent associations in order to make provision beforehand for these occasional revolts. Here and there the contest breaks out into riots.

Now and then the workers are victorious, but only for a time. The real fruit of their battles lies not in the immediate result, but in the ever improved means of communication that are created in modern industry and that place the workers of different localities in contact with one another. It was just this contact that was needed to centralize the numerous local struggles, all of the same character, into one national struggle between classes. But every class struggle is a political struggle. And that union, to attain which the burghers of the middle ages, with their miserable highways, required centuries, the modern proletarians, thanks to railways, achieve in a few years.

This organization of the proletarians into a class, and consequently into a political party, is continually being upset again by the competition between the workers themselves. But it ever rises up again; stronger, firmer, mightier. It compels legislative recognition of particular interests of the workers, by taking advantage of the divisions among the bourgeoisie itself. Thus the ten-hours' bill in England was carried.

Altogether, collisions between the classes of the old society further, in many ways, the course of development of the proletariat. The bourgoeoisie finds itself involved in a constant battle. At first with the aristocracy; later on, with those portions of the bourgeoisie itself whose interests have become antagonistic to the progress of industry; at all times with the bourgeoisie of foreign countries. In all these countries it sees itself compelled to appeal to the proletariat, to ask for its help, and

thus to drag it into the political arena. The bourgeoisie itself, therefore, supplies the proletariat with weapons for fighting the bourgeoisie.

Further, as we have already seen, entire sections of the ruling classes are, by the advance of industry, precipitated into the proletariat, or are at least threatened in their conditions of existence. These also supply the proletariat with fresh elements of enlightenment and progress.

Finally, in times when the class struggle nears the decisive hour, the process of dissolution going on within the ruling class, in fact within the whole range of old society, assumes such a violent, glaring character, that a small section of the ruling class cuts itself adrift and joins the revolutionary class, the class that holds the future in its hands. Just as, therefore, at an earlier period, a section of the nobility went over to the bourgeoisie, so now a portion of the bourgeoisie goes over to the proletariat, and in particular, a portion of the bourgeois ideologists, who have raised themselves to the level of comprehending theoretically the historical movement as a whole.

Of all the classes that stand face to face with the bourgeoisie to-day, the proletariat alone is a really revolutionary class. The other classes decay and finally disappear in the face of modern industry; the proletariat is its special and essential product.

The lower middle class, the small manufacturer, the shopkeeper, the artisan, the peasant, all these fight against the bourgeoisie to save from extinction their existence as fractions of the middle class. They are therefore not revolutionary, but conservative. Nay, more, they are reäctionary, for they try to roll back the wheel of history. If by chance they are revolutionary, they are so only in view of their impending transfer into the proletariat; they thus defend not their present, but their future interests, they desert their own standpoint to place themselves at that of the proletariat.

The "dangerous class," the social scum, that passively rotting class thrown off by the lowest layers of old society, may here and there be swept into the movement by a proletarian revolution; its conditions of life, however, prepare it far more for the part of a bribed tool of reactionary intrigue.

In the conditions of the proletariat, those of old society at large are already virtually swamped. The proletarian is without property; his relation to his wife and children has no longer anything in common with the bourgeois family relations; modern industrial labor, modern

subjection to capital, the same in England as in France, in America as in Germany, has stripped him of every trace of national character. Law, morality, religion are to him so many bourgeois prejudices, behind which lurk in ambush just as many bourgeois interests.

All the preceding classes that got the upper hand sought to fortify their already acquired status by subjecting society at large to their conditions of appropriation. The proletarians cannot become masters of the productive forces of society, except by abolishing their own previous mode of appropriation, and thereby also every other previous mode of appropriation. They have nothing of their own to secure and to fortify; their mission is to destroy all previous securities for, and insurances of, individual property.

All previous historical movements were movements of minorities, or in the interest of minorities. The proletarian movement is the self-conscious, independent movement of the immense majority, in the interest of the immense majority. The proletariat, the lowest stratum of our present society, cannot stir, cannot raise itself up, without the whole super-incumbent strata of official society being sprung into the air.

Though not in substance, yet in form, the struggle of the proletariat with the bourgeoisie is at first a national struggle. The proletariat of each country must, of course, first of all settle matters with its own bourgeoisie.

In depicting the most general phases of the development of the proletariat, we traced the more or less veiled civil war, raging within existing society, up to the point where that war breaks out into open revolution, and where the violent overthrow of the bourgeoisie lays the foundation for the sway of the proletariat.

Hitherto every form of society has been based, as we have already seen, on the antagonism of oppressing and oppressed classes. But in order to oppress a class certain conditions must be assured to it, under which it can at least continue its slavish existence. The serf, in the period of serfdom, raised himself to membership in the Commune, just as the petty bourgeois, under the yoke of feudal absolutism, managed to develop into a bourgeois. The modern laborer, on the contrary, instead of rising with the progress of industry, sinks deeper and deeper below the conditions of existence of his own class. He becomes a pauper, and pauperism develops more rapidly than population and wealth. And here it becomes evident that the bourgeoisie is unfit any longer to be the ruling class in society and to impose its conditions of

existence upon society as an overriding law. It is unfit to rule because it is incompetent to assure an existence to its slave within his slavery, because it cannot help letting him sink into such a state that it has to feed him instead of being fed by him. Society can no longer live under this bourgeoisie; in other words, its existence is no longer compatible with society.

The essential condition for the existence, and for the sway of the bourgeois class, is the formation and augmentation of capital; the condition for capital is wage-labor. Wage-labor rests exclusively on competition between the laborers. The advance of industry, whose involuntary promoter is the bourgeoisie, replaces the isolation of the laborers, due to competition, by their revolutionary combination, due to association. The development of modern industry, therefore, cuts from under its feet the very foundation on which the bourgeoisie produces and appropriates products. What the bourgeoisie therefore produces, above all, are its own grave diggers. Its fall and the victory of the proletariat are equally inevitable.

## II.

### Proletarians and Communists

In what relation do the Communists stand to the proletarians as a whole?

The Communists do not form a separate party opposed to other working class parties.

They have no interests separate and apart from those of the proletariat as a whole.

They do not set up any sectarian principles of their own by which to shape and mould the proletarian movement.

The Communists are distinguished from the other working class parties by this only: 1. In the national struggles of the proletarians of the different countries, they point out and bring to the front the common interests of the entire proletariat, independently of all nationality. 2. In the various stages of development which the struggle of the working class against the bourgeoisie has to pass through, they always and everywhere represent the interests of the movement as a whole.

The Communists, therefore, are on the one hand, practically the most advanced and resolute section of the working class parties of

every country, that section which pushes forward all others; on the other hand, theoretically they have over the great mass of the proletariat the advantage of clearly understanding the line of march, the conditions, and the ultimate general results of the proletarian movement.

The immediate aim of the Communists is the same as that of all the other proletarian parties: formation of the proletariat into a class, overthrow of the bourgeois supremacy, conquest of political power by the proletariat.

The theoretical conclusions of the Communists are in no way based on ideas or principles that have been invented, or discovered, by this or that would-be universal reformer.

They merely express, in general terms, actual relations springing from an existing class struggle, from a historical movement going on under our very eyes. The abolition of existing property relations is not at all a distinctive feature of Communism.

All property relations in the past have continually been subject to historical change, consequent upon the change in historical conditions.

The French revolution, for example, abolished feudal property in favor of bourgeois property.

The distinguishing feature of Communism is not the abolition of property generally, but the abolition of bourgeois property. But modern bourgeois private property is the final and most complete expression of the system of producing and appropriating products, that is, based on class antagonisms, on the exploitation of the many by the few.

In this sense the theory of the Communists may be summed up in the single sentence: Abolition of private property.

We Communists have been reproached with the desire of abolishing the right of personally acquiring property as the fruit of a man's own labor, which property is alleged to be the groundwork of all personal freedom, activity and independence.

Hard-won, self-acquired, self-earned property! Do you mean the property of the petty artisan and of the small peasant, a form of property that preceded the bourgeois form? There is no need to abolish that; the development of industry has to a great extent already destroyed it, and is still destroying it daily.

Or do you mean modern bourgeois private property?

But does wage labor create any property for the laborer? Not a bit. It creates capital, *i. e.*, that kind of property which exploits wage-labor,

and which cannot increase except on condition of begetting a new supply of wage-labor for fresh exploitation. Property in its present form is based on the antagonism of capital and wage-labor. Let us examine both sides of this antagonism.

To be a capitalist, is to have not only a purely personal, but a social status in production. Capital is a collective product, and only by the united action of many members, nay, in the last resort, only by the united action of all members of society, can it be set in motion.

Capital is therefore not a personal, it is a social power.

When, therefore, capital is converted into common property, into the property of all members of society, personal property is not thereby transformed into social property. It is only the social character of the property that is changed. It loses its class character.

Let us now take wage-labor.

The average price of wage-labor is the minimum wage, *i. e.,* that quantum of the means of subsistence, which is absolutely requisite to keep the laborer in bare existence as a laborer. What, therefore, the wage-laborer appropriates by means of his labor, merely suffices to prolong and reproduce a bare existence. We by no means intend to abolish this personal appropriation of the products of labor, an appropriation that is made for the maintenance and reproduction of human life, and that leaves no surplus wherewith to command the labor of others. All that we want to do away with is the miserable character of this appropriation, under which the laborer lives merely to increase capital, and is allowed to live only in so far as the interest of the ruling class requires it.

In bourgeois society living labor is but a means to increase accumulated labor. In Communist society accumulated labor is but a means to widen, to enrich, to promote the existence of the laborer.

In bourgeois society, therefore, the past dominates the present; in Communist society the present dominates the past. In bourgeois society capital is independent and has individuality, while the living person is dependent and has no individuality.

And the abolition of this state of things is called by the bourgeois: abolition of individuality and freedom! And rightly so. The abolition of bourgeois individuality, bourgeois independence, and bourgeois freedom is undoubtedly aimed at.

By freedom is meant, under the present bourgeois conditions of production, free trade, free selling and buying.

But if selling and buying disappears, free selling and buying dis-

appears also. This talk about free selling and buying, and all the other "brave words" of our bourgeoisie about freedom in general, have a meaning, if any, only in contrast with restricted selling and buying, with the fettered traders of the middle ages, but have no meaning when opposed to the Communistic abolition of buying and selling, of the bourgeois conditions of production, and of the bourgeoisie itself.

You are horrified at our intending to do away with private property. But in your existing society private property is already done away with for nine-tenths of the population; its existence for the few is solely due to its non-existence in the hands of those nine-tenths. You reproach us, therefore, with intending to do away with a form of property, the necessary condition for whose existence is the non-existence of any property for the immense majority of society.

In one word, you reproach us with intending to do away with your property. Precisely so: that is just what we intend.

From the moment when labor can no longer be converted into capital, money, or rent, into a social power capable of being monopolized, *i. e.*, from the moment when individual property can no longer be transformed into bourgeois property, into capital, from that moment, you say, individuality vanishes!

You must therefore confess, that by "individual" you mean no other person than the bourgeois, than the middle class owner of property. This person must, indeed, be swept out of the way, and made impossible.

Communism deprives no man of the power to appropriate the products of society: all that it does is to deprive him of the power to subjugate the labor of others by means of such appropriation.

It has been objected, that upon the abolition of private property all work will cease and universal laziness will overtake us.

According to this, bourgeois society ought long ago to have gone to the dogs through sheer idleness; for those of its members who work, acquire nothing, and those who acquire anything, do not work. The whole of this objection is but another expression of tautology, that there can no longer be any wage-labor when there is no longer any capital.

All objections against the Communistic mode of producing and appropriating material products have, in the same way, been urged against the Communistic modes of producing and appropriating intellectual products. Just as, to the bourgeois, the disappearance of class property is the disappearance of production itself, so the disappearance

of class culture is to him identical with the disappearance of all culture.

That culture, the loss of which he laments, is, for the enormous majority, a mere training to act as a machine.

But don't wrangle with us so long as you apply to our intended abolition of bourgeois property, the standard of your bourgeois notions of freedom, culture, law, etc. Your very ideas are but the outgrowth of the conditions of your bourgeois production and bourgeois property, just as your jurisprudence is but the will of your class made into a law for all, a will, whose essential character and direction are determined by the economical conditions of existence of your class.

The selfish misconception that induces you to transform into eternal laws of nature and of reason, the social forms springing from your present mode of production and form of property—historical relations that rise and disappear in the progress of production—the misconception you share with every ruling class that has preceded you. What you see clearly in the case of ancient property, what you admit in the case of feudal property, you are of course forbidden to admit in the case of your own bourgeois form of property.

Abolition of the family! Even the most radical flare up at this infamous proposal of the Communists.

On what foundation is the present family, the bourgeois family, based? On capital, on private gain. In its completely developed form this family exists only among the bourgeoisie. But this state of things finds its complement in the practical absence of the family among the proletarians, and in public prostitution.

The bourgeois family will vanish as a matter of course when its complement vanishes, and both will vanish with the vanishing of capital.

Do you charge us with wanting to stop the exploitation of children by their parents? To this crime we plead guilty.

But, you will say, we destroy the most hallowed of relations, when we replace home education by social.

And your education! Is not that also social, and determined by the social conditions under which you educate, by the intervention, direct or indirect, of society by means of schools, etc.? The Communists have not invented the intervention of society in education; but they do seek to alter the character of that intervention, and to rescue education from the influence of the ruling class.

The bourgeois clap-trap about the family and education, about the hallowed co-relation of parent and child become all the more disgusting,

as, by the action of modern industry, all family ties among the proletarians are torn asunder, and their children transformed into simple articles of commerce and instruments of labor.

But you Communists would introduce community of women, screams the whole bourgeoisie in chorus.

The bourgeois sees in his wife a mere instrument of production. He hears that the instruments of production are to be exploited in common, and naturally can come to no other conclusion than that the lot of being common to all will likewise fall to the women.

He has not even a suspicion that the real point aimed at is to do away with the status of women as mere instruments of production.

For the rest nothing is more ridiculous than the virtuous indignation of our bourgeois at the community of women which, they pretend, is to be openly and officially established by the Communists. The Communists have no need to introduce community of women; it has existed almost from time immemorial.

Our bourgeois, not content with having the wives and daughters of their proletarians at their disposal, not to speak of common prostitutes, take the greatest pleasure in seducing each other's wives.

Bourgeois marriage is in reality a system of wives in common, and thus, at the most, what the Communists might possibly be reproached with, is that they desire to introduce, in substitution for a hypocritically concealed, an openly legalized community of women. For the rest it is self-evident that the abolition of the present system of production must bring with it the abolition of the community of women springing from that system, *i. e.*, of prostitution, both public and private.

The Communists are further reproached with desiring to abolish countries and nationality.

The workingmen have no country. We cannot take from them what they have not got. Since the proletariat must first of all acquire political supremacy, must rise to be the leading class of the nation, must constitute itself the nation, it is, so far, itself national, though not in the bourgeois sense of the word.

National differences and antagonisms between peoples are daily more and more vanishing, owing to the development of the bourgeoisie, to freedom of commerce, to the world's market, to uniformity in the mode of production and in the conditions of life corresponding thereto.

The supremacy of the proletariat will cause them to vanish still faster. United action, of the leading civilized countries at least, is one of the first conditions for the emancipation of the proletariat.

In proportion as the exploitation of one individual by another is put an end to, the exploitation of one nation by another will also be put an end to. In proportion as the antagonism between classes within the nation vanishes, the hostility of one nation to another will come to an end.

The charges against Communism made from a religious, a philosophical, and, generally, from an ideological standpoint are not deserving of serious examination.

Does it require deep intuition to comprehend that man's ideas, views, and conceptions, in one word, man's consciousness, changes with every change in the conditions of his material existence, in his social relations and in his social life?

What else does the history of ideas prove, than that intellectual production changes its character in proportion as material production is changed? The ruling ideas of each age have ever been the ideas of its ruling class.

When people speak of ideas that revolutionize society they do but express the fact that within the old society the elements of a new one have been created, and that the dissolution of the old ideas keeps even pace with the dissolution of the old conditions of existence.

When the ancient world was in its last throes the ancient religions were overcome by Christianity. When Christian ideas succumbed in the eighteenth century to rationalist ideas, feudal society fought its death battle with the then revolutionary bourgeoisie. The ideas of religious liberty and freedom of conscience merely gave expression to the sway of free competition within the domain of knowledge.

"Undoubtedly," it will be said, "religious, moral, philosophical and juridical ideas have been modified in the course of historical development. But religion, morality, philosophy, political science, and law, constantly survived this change."

"There are besides eternal truths, such as Freedom, Justice, etc., that are common to all states of society. But Communism abolishes eternal truths, it abolishes all religion and all morality, instead of constituting them on a new basis; it therefore acts in contradiction to all past historical experience."

What does this accusation reduce itself to? The history of all past society has consisted in the development of class antagonisms, antagonisms that assumed different forms at different epochs.

But whatever form they may have taken, one fact is common to all

past ages, viz., the exploitation of one part of society by the other. No wonder, then, that the social consciousness of past ages, despite all the multiplicity and variety it displays, moves within certain common forms, or general ideas, which cannot completely vanish except with the total disappearance of class antagonisms.

The Communist revolution is the most radical rupture with traditional property relations; no wonder that its development involves the most radical rupture with traditional ideas.

But let us have done with the bourgeois objections to Communism.

We have seen above that the first step in the revolution by the working class is to raise the proletariat to the position of the ruling class; to win the battle of democracy.

The proletariat will use its political supremacy to wrest, by degrees, all capital from the bourgeoisie; to centralize all instruments of production in the hands of the State, *i. e.*, of the proletariat organized as the ruling class; and to increase the total of productive forces as rapidly as possible.

Of course, in the beginning this cannot be effected except by means of despotic inroads on the rights of property and on the conditions of bourgeois production; by means of measures, therefore, which appear economically insufficient and untenable, but which, in the course of the movement, outstrip themselves, necessitate further inroads upon the old social order and are unavoidable as a means of entirely revolutionizing the mode of production.

These measures will, of course, be different in different countries.

Nevertheless in the most advanced countries the following will be pretty generally applicable:

1. Abolition of property in land and application of all rents of land to public purposes.
2. A heavy progressive or graduated income tax.
3. Abolition of all right of inheritance.
4. Confiscation of the property of all emigrants and rebels.
5. Centralization of credit in the hands of the State, by means of a national bank with State capital and an exclusive monopoly.
6. Centralization of the means of communication and transport in the hands of the State.
7. Extension of factories and instruments of production owned by the State; the bringing into cultivation of waste lands, and the improvement of the soil generally in accordance with a common plan.

8. Equal liability of all to labor. Establishment of industrial armies, especially for agriculture.

9. Combination of agriculture with manufacturing industries; gradual abolition of the distinction between town and country, by a more equable distribution of the population over the country.

10. Free education for all children in public schools. Abolition of children's factory labor in its present form. Combination of education with industrial production, etc., etc.

When, in the course of development, class distinctions have disappeared and all production has been concentrated in the hands of a vast association of the whole nation, the public power will lose its political character. Political power, properly so called, is merely the organized power of one class for oppressing another. If the proletariat during its contest with the bourgeoisie is compelled, by the force of circumstances, to organize itself as a class, if, by means of a revolution, it makes itself the ruling class, and, as such, sweeps away by force the old conditions of production, then it will, along with these conditions, have swept away the conditions for the existence of class antagonisms, and of classes generally, and will thereby have abolished its own supremacy as a class.

In place of the old bourgeois society with its classes and class antagonisms we shall have an association in which the free development of each is the condition for the free development of all.

# FRIEDRICH ENGELS

Friedrich Engels was born at Barmen, Germany, 1820. He was a lifelong friend of Karl Marx and with him is one of the founders of German socialism. Since 1842 he lived mostly in England. He died in 1896.

## SCIENTIFIC SOCIALISM

The new German philosophy culminated in the Hegelian system. In this system—and herein is its great merit—for the first time the whole world, natural, historical, intellectual, is represented as a process, *i. e.*, as in constant motion, change, transformation, development; and the attempt is made to trace out the internal connection that makes a continuous whole of all this movement and development. From this point of view the history of mankind no longer appeared as a wild whirl of senseless deeds of violence, all equally condemnable at the judgment seat of mature philosophic reason, and which are best forgotten as quickly as possible; but as the process of evolution of man himself. It was now the task of the intellect to follow the gradual march of this process through all its devious ways, and to trace out the inner law running through all its apparently accidental phenomena.

That the Hegelian system did not solve the problem it propounded is here immaterial. Its epoch-making merit was that it propounded the problem. This problem is one that no single individual will ever be able to solve. Although Hegel was—with Saint Simon—the most encyclopædic mind of his time, yet he was limited, first, by the necessarily limited extent of his own knowledge, and, second, by the limited extent and depth of the knowledge and conceptions of his age. To these limits a third must be added. Hegel was an idealist. To him the thoughts within his brain were not the more or less abstract pictures of actual things and processes, but, conversely, things and their evolution were only the realised pictures of the "Idea," existing somewhere from eternity before the world was. This way of thinking turned everything

upside down, and completely reversed the actual connection of things in the world. Correctly and ingeniously as many individual groups of facts were grasped by Hegel, yet, for the reasons just given, there is much that is botched, artificial, laboured, in a word, wrong in point of detail. The Hegelian system, in itself, was a colossal miscarriage—but it was also the last of its kind. It was suffering, in fact, from an internal and incurable contradiction. Upon the one hand, its essential proposition was the conception that human history is a process of evolution, which, by its very nature, cannot find its intellectual final term in the discovery of any so-called absolute truth. But, on the other hand, it laid claim to being the very essence of this absolute truth. A system of natural and historical knowledge, embracing everything, and final for all time, is a contradiction to the fundamental law of dialectic reasoning. This law, indeed, by no means excludes, but, on the contrary, includes the idea that the systematic knowledge of the external universe can make giant strides from age to age.

The perception of the fundamental contradiction in German idealism led necessarily back to materialism, but *nota bene,* not to the simply metaphysical, exclusively mechanical materialism of the eighteenth century. Old materialism looked upon all previous history as a crude heap of irrationality and violence; modern materialism sees in it the process of evolution of humanity, and aims at discovering the laws thereof. With the French of the eighteenth century, and even with Hegel, the conception obtained of Nature as a whole, moving in narrow circles, and forever immutable, with its eternal celestial bodies, as Newton, and unalterable organic species, as Linnæus taught. Modern materialism embraces the more recent discoveries of natural science, according to which Nature also has its history in time, the celestial bodies, like the organic species that, under favourable conditions, people them, being born and perishing. And even if Nature, as a whole, must still be said to move in recurrent cycles, these cycles assume infinitely larger dimensions. In both aspects, modern materialism is essentially dialectic, and no longer requires the assistance of that sort of philosophy which, queen-like, pretended to rule the remaining mob of sciences. As soon as each special science is bound to make clear its position in the great totality of things and of our knowledge of things, a special science dealing with this totality is superfluous or unnecessary. That which still survives of all earlier philosophy is the science of thought and its laws—formal logic and dialectics. Everything else is subsumed in the positive science of Nature and history.

Whilst, however, the revolution in the conception of Nature could only be made in proportion to the corresponding positive materials furnished by research, already much earlier certain historical facts had occurred which led to a decisive change in the conception of history. In 1831, the first working-class rising took place in Lyons; between 1838 and 1842, the first national working-class movement, that of the English Chartists, reached its height. The class struggle between proletariat and bourgeoisie came to the front in the history of the most advanced countries in Europe, in proportion to the development, upon the one hand, of modern industry, upon the other, of the newly-acquired political supremacy of the bourgeoisie. Facts more and more strenuously gave the lie to the teachings of bourgeois economy as to the identity of the interests of capital and labour, as to the universal harmony and universal prosperity that would be the consequence of unbridled competition. All these things could no longer be ignored, any more than the French and English Socialism, which was their theoretical, though very imperfect, expression. But the old idealist conception of history, which was not yet dislodged, knew nothing of class struggles based upon economic interests, knew nothing of economic interests; production and all economic relations appeared in it only as incidental, subordinate elements in the "history of civilisation."

The new facts made imperative a new examination of all past history. Then it was seen that *all* past history, with the exception of its primitive stages, was the history of class struggles; that these warring classes of society are always the products of the modes of production and of exchange—in a word, of the *economic* conditions of their time; that the economic structure of society always furnishes the real basis, starting from which we can alone work out the ultimate explanation of the whole superstructure of juridical and political institutions, as well as of the religious, philosophical, and other ideas of a given historical period. Hegel had freed history from metaphysics—he had made it dialectic; but his conception of history was essentially idealistic. But now idealism was driven from its last refuge, the philosophy of history; now a materialistic treatment of history was propounded, and a method found of explaining man's "knowing" by his "being," instead of, as heretofore, his "being" by his "knowing."

From that time forward Socialism was no longer an accidental discovery of this or that ingenious brain, but the necessary outcome of the struggle between two historically developed classes—the proletariat and the bourgeoisie. Its task was no longer to manufacture a system of

society as perfect as possible, but to examine the historico-economic succession of events from which these classes and their antagonism had of necessity sprung, and to discover in the economic conditions thus created the means of ending the conflict. But the Socialism of earlier days was incompatible with this materialistic conception as the conception of Nature of the French materialists was with dialectics and modern natural science. The Socialism of earlier days certainly criticised the existing capitalistic mode of production and its consequences. But it could not expiain them, and therefore could not get the mastery of them. It could only simply reject them as bad. The more strongly this earlier Socialism denounced the exploitation of the working-class, inevitable under Capitalism, the less able was it clearly to show in what this exploitation consisted and how it arose. But for this it was necessary—(1) to present the capitalistic method of production in its historical connection and its inevitableness during a particular historical period, and therefore, also, to present its inevitable downfall; and (2) to lay bare its essential character, which was still a secret. This was done by the discovery of *surplus-value*. It was shown that the appropriation of unpaid labour is the basis of the capitalist mode of production and of the exploitation of the worker that occurs under it; that even if the capitalist buys the labour-power of his labourer at its full value as a commodity on the market, he yet extracts more value from it than he paid for; and that in the ultimate analysis this surplus-value forms those sums of value from which are heaped up the constantly increasing masses of capital in the hands of the possessing classes. The genesis of capitalist production and the production of capital were both explained.

These two great discoveries, the materialistic conception of history and the revelation of the secret of capitalistic production through surplus-value, we owe to Marx. With these discoveries Socialism became a science. The next thing was to work out all its details and relations.

The materialist conception of history starts from the proposition that the production of the means to support human life and, next to production, the exchange of things produced, is the basis of all social structure; that in every society that has appeared in history, the manner in which wealth is distributed and society divided into classes or orders, is dependent upon what is produced, how it is produced, and how the products are exchanged. From this point of view the final causes of all social changes and political revolutions are to be sought, not in men's brains, not in man's better insight into eternal truth and justice, but in

changes in the modes of production and exchange. They are to be sought, not in the *philosophy,* but in the *economics* of each particular epoch. The growing perception that existing social institutions are unreasonable and unjust, that reason has become unreason, and right wrong, is only proof that in the modes of production and exchange changes have silently taken place, with which the social order, adapted to earlier economic conditions, is no longer in keeping. From this it also follows that the means of getting rid of the incongruities that have been brought to light, must also be present, in a more or less developed condition, within the changed modes of production themselves. These means are not to be invented by deduction from fundamental principles, but are to be discovered in the stubborn facts of the existing system of production.

What is, then, the position of modern Socialism in this connexion?

The present structure of society—this is now pretty generally conceded—is the creation of the ruling class of to-day, of the bourgeoisie. The mode of production peculiar to the bourgeoisie, known, since Marx, as the capitalist mode of production, was incompatible with the feudal system, with the privileges it conferred upon individuals, entire social ranks and local corporations, as well as with the hereditary ties of subordination which constituted the framework of its social organisation. The bourgeoisie broke up the feudal system and built upon its ruins the capitalist order of society, the kingdom of free competition, of personal liberty, of the equality, before the law, of all commodity owners, of all the rest of the capitalist blessings. Thenceforward the capitalist mode of production could develop in freedom. Since steam, machinery, and the making of machines by machinery transformed the older manufacture into modern industry, the productive forces evolved under the guidance of the bourgeoisie developed with a rapidity and in a degree unheard of before. But just as the older manufacture, in its time, and handicraft, becoming more developed under its influence, had come into collision with the feudal trammels of the guilds, so now modern industry, in its more complete development, comes into collision with the bounds within which the capitalistic mode of production holds it confined. The new productive forces have already outgrown the capitalistic mode of using them. And this conflict between productive forces and modes of production is not a conflict engendered in the mind of man, like that between original sin and divine justice. It exists, in fact, objectively, outside us, independently of the will and actions even of the men that have brought it on. Modern Socialism is nothing but the

reflex, in thought, of this conflict in fact; its ideal reflection in the minds, first, of the class directly suffering under it, the working-class.

Now, in what does this conflict consist?

Before capitalistic production, *i. e.*, in the Middle Ages, the system of petty industry obtained generally, based upon the private property of the labourers in their means of production; in the country, the agriculture of the small peasant, freeman or serf; in the towns, the handicrafts organized in guilds. The instruments of labour—land, agricultural implements, the workshop, the tool—were the instruments of labour of single individuals, adapted for the use of one worker, and, therefore, of necessity, small, dwarfish, circumscribed. But, for this very reason they belonged, as a rule, to the producer himself. To concentrate these scattered, limited means of production, to enlarge them, to turn them into the powerful levers of production of the present day—this was precisely the historic rôle of capitalist production and of its upholder, the bourgeoisie. In the fourth section of "Capital" Marx has explained in detail, how since the fifteenth century this has been historically worked out through the three phases of simple co-operation, manufacture and modern industry. But the bourgeoisie, as is also shown there, could not transform these puny means of production into mighty productive forces, without transforming them, at the same time, from means of production of the individual into *social* means of production only workable by a collectivity of men. The spinning-wheel, the handloom, the blacksmith's hammer, were replaced by the spinning-machine, the power-loom, the steam-hammer; the individual workshop, by the factory implying the co-operation of hundreds and thousands of workmen. In like manner, production itself changed from a series of individual into a series of social acts, and the products from individual to social products. The yarn, the cloth, the metal articles that now came out of the factory were the joint product of many workers, through whose hands they had successively to pass before they were ready. No one person could say of them: "I made that; this is my product."

But where, in a given society, the fundamental form of production is that spontaneous division of labour which creeps in gradually and not upon any preconceived plan, there the products take on the form of commodities, whose mutual exchange, buying and selling, enable the individual producers to satisfy their manifold wants. And this was the case in the Middle Ages. The peasant, *e. g.*, sold to the artisan agricultural products and bought from him the products of handicraft. Into

this society of individual producers, of commodity-producers, the new mode of production thrust itself. In the midst of the old division of labour, grown up spontaneously and upon *no definite plan*, which had governed the whole of society, now arose division of labour upon a definite plan, as organised in the factory; side by side with *individual* production appeared *social* production. The products of both were sold in the same market, and, therefore, at prices at least approximately equal. But organisation upon a definite plan was stronger than spontaneous division of labour. The factories working with the combined social forces of a collectivity of individuals produced their commodities far more cheaply than the individual small producers. Individual production succumbed in one department after another. Socialised production revolutionised all the old methods of production. But its revolutionary character was, at the same time, so little recognised, that it was, on the contrary, introduced as a means of increasing and developing the production of commodities. When it arose, it found ready-made, and made liberal use of, certain machinery for the production and exchange of commodities; merchants' capital, handicraft, wage-labour. Socialised production thus introducing itself as a new form of the production of commodities, it was a matter of course that under it the old forms of appropriation remained in full swing, and were applied to its products as well.

In the mediæval stage of evolution of the production of commodities, the question as to the owner of the product of labour could not arise. The individual producer, as a rule, had, from raw material belonging to himself, and generally his own handiwork, produced it with his own tools, by the labour of his own hands or of his family. There was no need for him to appropriate the new product. It belonged wholly to him, as a matter of course. His property in the product was, therefore, based *upon his own labour*. Even where external help was used, this was, as a rule, of little importance, and very generally was compensated by something other than wages. The apprentices and journeymen of the guilds worked less for board and wages than for education, in order that they might become master craftsmen themselves.

Then came the concentration of the means of production and of the producers in large workshops and manufactories, their transformation into actual socialised means of production and socialised producers. But the socialised producers and means of production and their products were still treated, after this change, just as they had been before,

*i. e.,* as the means of production and the products of individuals. Hitherto, the owner of the instruments of labour had himself appropriated the product, because, as a rule, it was his own product and the assistance of others was the exception. Now the owner of the instruments of labour always appropriated to himself the product, although it was no longer *his* product, but exclusively the product of the *labour of others.* Thus, the products now produced socially were not appropriated by those who had actually set in motion the means of production and actually produced the commodities, but by the *capitalists.* The means of production, and production itself, had become in essence socialised. But they were subjected to a form of appropriation which presupposes the private production of individuals, under which, therefore, every one owns his own product and brings it to market. The mode of production is subjected to this form of appropriation, although it abolishes the conditions upon which the latter rests.

This contradiction, which gives to the new mode of production its capitalistic character, *contains the germ of the whole of the social antagonisms of to-day.* The greater the mastery obtained by the new mode of production over all important fields of production and in all manufacturing countries, the more it reduced individual production to an insignificant residuum, *the more clearly was brought out the incompatibility of socialised production with capitalistic appropriation.*

The first capitalists found, as we have said, alongside of other forms of labour, wage-labour ready-made for them on the market. But it was exceptional, complementary, accessory, transitory wage-labour. The agricultural labourer, though, upon occasion, he hired himself out by the day, had a few acres of his own land on which he could at all events live at a pinch. The guilds were so organised that the journeyman of to-day became the master of to-morrow. But all this changed, as soon as the means of production became socialised and concentrated in the hands of capitalists. The means of production, as well as the product, of the individual producer became more and more worthless; there was nothing left for him but to turn wage-worker under the capitalist. Wage-labour, aforetime the exception and accessory, now became the rule and basis of all production; aforetime complementary, it now became the sole remaining function of the worker. The wage-worker for a time became a wage-worker for life. The number of these permanent wage-workers was further enormously increased by the breaking-up of the feudal system that occurred at the same time, by the disbanding of the retainers of the feudal lords, the eviction of the

peasants from their homesteads, etc. The separation was made complete between the means of production concentrated in the hands of the capitalists on the one side, and the producers, possessing nothing but their labour-power, on the other. *The contradiction between socialised production and capitalistic appropriation manifested itself as the antagonism of proletariat and bourgeoisie.*

We have seen that the capitalistic mode of production thrust its way into a society of commodity-producers, of individual producers, whose social bond was the exchange of their products. But every society, based upon the production of commodities, has this peculiarity: that the producers have lost control over their own social inter-relations. Each man produces for himself with such means of production as he may happen to have, and for such exchange as he may require to satisfy his remaining wants. No one knows how much of his particular article is coming on the market, nor how much of it will be wanted. No one knows whether his individual product will meet an actual demand, whether he will be able to make good his cost of production or even to sell his commodity at all. Anarchy reigns in socialised production.

But the production of commodities, like every other form of production, has its peculiar, inherent laws inseparable from it; and these laws work, despite anarchy, in and through anarchy. They reveal themselves in the only persistent form of social inter-relations, *i. e.*, in exchange, and here they affect the individual producers as compulsory laws of competition. They are, at first, unknown to these producers themselves, and have to be discovered by them gradually and as the result of experience. They work themselves out, therefore, independently of the producers, and in antagonism to them, as inexorable natural laws of their particular form of production. The product governs the producers.

In mediæval society, especially in the earlier centuries, production was essentially directed towards satisfying the wants of the individual. It satisfied, in the main, only the wants of the producer and his family. Where relations of personal dependence existed, as in the country, it also helped to satisfy the wants of the feudal lord. In all this there was, therefore, no exchange; the products, consequently, did not assume the character of commodities. The family of the peasant produced almost everything they wanted; clothes and furniture, as well as means of subsistence. Only when it began to produce more than was sufficient to supply its own wants and the payments in kind to the feudal lord, only

then did it also produce commodities. This surplus, thrown into socialised exchange and offered for sale, became commodities.

The artisans of the towns, it is true, had from the first to produce for exchange. But they, also, themselves supplied the greatest part of their own individual wants. They had gardens and plots of land. They turned their cattle out into the communal forest, which, also, yielded them timber and firing. The women spun flax, wool, and so forth. Production for the purpose of exchange, production of commodities, was only in its infancy. Hence, exchange was restricted, the market narrow, the methods of production stable; there was local exclusiveness without, local unity within; the mark in the country, in the town, the guild.

But with the extension of the production of commodities, and especially with the introduction of the capitalist mode of production, the laws of commodity-production, hitherto latent, came into action more openly and with greater force. The old bonds were loosened, the old exclusive limits broken through, the producers were more and more turned into independent, isolated producers of commodities. It became apparent that the production of society at large was ruled by absence of plan, by accident, by anarchy; and this anarchy grew to greater and greater height. But the chief means by aid of which the capitalist mode of production intensified this anarchy of socialised production, was the exact opposite of anarchy. It was the increasing organisation of production, upon a social basis, in every individual productive establishment. By this, the old, peaceful, stable condition of things was ended. Wherever this organisation of production was introduced into a branch of industry, it brooked no other method of production by its side. The field of labour became a battle-ground. The great geographical discoveries, and the colonisation following upon them, multiplied markets and quickened the transformation of handicraft into manufacture. The war did not simply break out between the individual producers of particular localities. The local struggles begat in their turn national conflicts, the commercial wars of the seventeenth and the eighteenth centuries.

Finally, modern industry and the opening of the world-market made the struggle universal, and at the same time gave it an unheard-of virulence. Advantages in natural or artificial conditions of production now decide the existence or non-existence of individual capitalists, as well as of whole industries and countries. He that falls is remorselessly cast aside. It is the Darwinian struggle of the individual for existence transferred from Nature to society with intensified violence. The con-

ditions of existence natural to the animal appear as the final term of human development. The contradiction between socialised production and capitalistic appropriation now presents itself as *an antagonism between the organisation of production in the individual workshop and the anarchy of production in society generally.*

The capitalistic mode of production moves in these two forms of the antagonism immanent to it from its very origin. It is never able to get out of that "vicious circle," which Fourier had already discovered. What Fourier could not, indeed, see in his time, is, that this circle is gradually narrowing; that the movement becomes more and more a spiral, and must come to an end, like the movement of the planets, by collision with the centre. It is the compelling force of anarchy in the production of society at large that more and more completely turns the great majority of men into proletarians; and it is the masses of the proletariat again who will finally put an end to anarchy in production. It is the compelling force of anarchy in social production that turns the limitless perfectibility of machinery under modern industry into a compulsory law by which every individual industrial capitalist must perfect his machinery more and more, under penalty of ruin.

But the perfecting of machinery is the making human labour superfluous. If the introduction and increase of machinery means the displacement of millions of manual, by a few machine workers, improvement in machinery means the displacement of more and more of the machine-workers themselves. It means, in the last instance, the production of a number of available wage-workers in excess of the average needs of capital, the formation of a complete industrial reserve army, as I called it in 1845, available at the times when industry is working at high pressure, to be cast out upon the street when the inevitable crash comes, a constant dead weight upon the limbs of the working-class in its struggle for existence with capital, a regulator for the keeping of wages down to the low level that suits the interests of capital. Thus it comes about, to quote Marx, that machinery becomes the most powerful weapon in the war of capital against the working-class; that the instruments of labour constantly tear the means of subistence out of the hands of the labourer; that the very product of the worker is turned into an instrument for his subjugation. Thus it comes about that the economising of the instruments of labour becomes at the same time, from the outset, the most reckless waste of labour-power, and robbery based upon the normal conditions under which labour functions; that machinery, "the most powerful instrument for shortening labour-time, becomes

the most unfailing means for placing every moment of the labourer's time and that of his family at the disposal of the capitalist for the purpose of expanding the value of his capital" ("Capital," English edition, p. 406). Thus it comes about that over-work of some becomes the preliminary condition for the idleness of others, and that modern industry, which hunts after new consumers over the whole world, forces the consumption of the masses at home down to a starvation minimum, and in doing thus destroys its own home market. "The law that always equilibrates the relative surplus population, or industrial reserve army, to the extent and energy of accumulation, this law rivets the labourer to capital more firmly than the wedges of Vulcan did Prometheus to the rock. It establishes an accumulation of misery, corresponding with accumulation of capital. Accumulation of wealth at one pole is, therefore, at the same time, accumulation of misery, agony of toil, slavery, ignorance, brutality, mental degradation, at the opposite pole, *i. e.*, on the side of the class that produces *its own product in the form of capital.*" (Marx' "Capital" [Sonnenschein & Co.], p. 661.) And to expect any other division of the products from the capitalistic mode of production is the same as expecting the electrodes of a battery not to decompose acidulated water, not to liberate oxygen at the positive, hydrogen at the negative pole, so long as they are connected with the battery.

We have seen that the ever-increasing perfectibility of modern machinery is, by the anarchy of social production, turned into a compulsory law that forces the individual industrial capitalist always to improve his machinery, always to increase its productive force. The bare possibility of extending the field of production is transformed for him into a similar compulsory law. The enormous expansive force of modern industry, compared with which that of gases is mere child's play, appears to us now as a *necessity* for expansion, both qualitative and quantitative, that laughs at all resistance. Such resistance is offered by consumption, by sales, by the markets for the products of modern industry. But the capacity for extension, extensive and intensive, of the markets is primarily governed by quite different laws, that work much less energetically. The extension of the markets cannot keep pace with the extension of production. The collision becomes inevitable, and as this cannot produce any real solution so long as it does not break in pieces the capitalist mode of production, the collisions become periodic. Capitalists production has begotten another "vicious circle."

As a matter of fact, since 1825, when the first general crisis broke out, the whole industrial and commercial world, production and exchange among all civilised peoples and their more or less barbaric hangers-on, are thrown out of joint about once every ten years. Commerce is at a standstill, the markets are glutted, products accumulate, as multitudinous as they are unsalable, hard cash disappears, credit vanishes, factories are closed, the mass of the workers are in want of the means of subsistence, because they have produced too much of the means of subsistence; bankruptcy follows upon bankruptcy, execution upon execution. The stagnation lasts for years; productive forces and products are wasted and destroyed wholesale, until the accumulated mass of commodities finally filter off, more or less depreciated in value, until production and exchange gradually begin to move again. Little by little the pace quickens. It becomes a trot. The industrial trot breaks into a canter, the canter in turn grows into the headlong gallop of a perfect steeplechase of industry, commercial credit, and speculation, which finally, after breakneck leaps, ends where it began—in the ditch of a crisis. And so over and over again. We have now, since the year 1825, gone through this five times, and at the present moment (1877) we are going through it for the sixth time. And the character of these crises is so clearly defined that Fourier hit all of them off, when he described the first as *"crise plethorique,"* a crisis from plethora.

In these crises, the contradiction between socialised production and capitalist appropriation ends in a violent explosion. The circulation of commodities is, for the time being, stopped. Money, the means of circulation, becomes a hindrance to circulation. All the laws of production and circulation of commodities are turned upside down. The economic collision has reached its apogee. ***The mode of production is in rebellion against the mode of exchange.***

The fact that the socialised organisation of production within the factory has developed so far that it has become incompatible with the anarchy of production in society, which exists side by side with and dominates it, is brought home to the capitalists themselves by the violent concentration of capital that occurs during crises, through the ruin of many large, and a still greater number of small, capitalists. The whole mechanism of the capitalist mode of production breaks down under the pressure of the productive forces, its own creations. It is no longer able to turn all this mass of means of production into capital. They lie fallow, and for that very reason the industrial reserve army must also lie

fallow. Means of production, means of subsistence, available labourers, all the elements of production and of general wealth, are present in abundance. But "abundance becomes the source of distress and want" (Fourier), because it is the very thing that prevents the transformation of the means of production and subsistence into capital. For in capitalistic society the means of production can only function when they have undergone a preliminary transformation into capital, into the means of exploiting human labour-power. The necessity of this transformation into capital of the means of production and subsistence stands like a ghost between these and the workers. It alone prevents the coming together of the material and personal levers of production; it alone forbids the means of production to function, the workers to work and live. On the one hand, therefore, the capitalistic mode of production stands convicted of its own incapacity to further direct these productive forces. On the other, these productive forces themselves, with increasing energy, press forward to the removal of the existing contradiction, to the abolition of their quality as capital, to the *practical recognition of their character as social productive forces.*

This rebellion of the productive forces, as they grow more and more powerful, against their quality as capital, this stronger and stronger command that their social character shall be recognised, forces the capitalist class itself to treat them more and more as social productive forces, so far as this is possible under capitalist conditions. The period of industrial high pressure, with its unbounded inflation of credit, not less than the crash itself, by the collapse of great capitalist establishments, tends to bring about that form of the socialisation of great masses of means of production, which we meet with in the different kinds of joint-stock companies. Many of these means of production and of distribution are, from the outset, so colossal, that, like the railroads, they exclude all other forms of capitalistic exploitation. At a further stage of evolution this form also becomes insufficient. The producers on a large scale in a particular branch of industry in a particular country unite in a "Trust," a union for the purpose of regulating production. They determine the total amount to be produced, parcel it out among themselves, and thus enforce the selling price fixed beforehand. But trusts of this kind, as soon as business becomes bad, are generally liable to break up, and, on this very account, compel a yet greater concentration of association. The whole of the particular industry is turned into one gigantic joint-stock com-

pany; internal competition gives place to the internal monopoly of this one company. This has happened in 1890 with the English alkali production, which is now, after the fusion of 48 large works, in the hands of one company, conducted upon a single plan, and with a capital of £6,000,000.

In the trusts, freedom of competition changes into its very opposite —into monopoly; and the production without any definite plan of capitalistic society capitulates to the production upon a definite plan of the invading socialistic society. Certainly this is so far still to the benefit and advantage of the capitalists. But in this case the exploitation is so palpable that it must break down. No nation will put up with production conducted by trusts, with so barefaced an exploitation of the community by a small band of dividend-mongers.

In any case, with trusts or without, the official representative of capitalist society—the State—will ultimately have to undertake the direction of production. This necessity for conversion into State-property is felt first in the great institutions for intercourse and communication—the post-office, the telegraphs, the railways.

If the crises demonstrate the incapacity of the bourgeoisie for managing any longer modern productive forces, the transformation of the great establishments for production and distribution into joint-stock companies, trusts, and State property, show how unnecessary the bourgeoisie are for that purpose. All the social functions of the capitalists are now performed by salaried employees. The capitalist has no further social function than that of pocketing dividends, tearing off coupons, and gambling on the Stock Exchange, where the different capitalists despoil one another of their capital. At first the capitalistic mode of production forces out the workers. Now it forces out the capitalists, and reduces them, just as it reduced the workers, to the ranks of the surplus population, although not immediately into those of the industrial reserve army.

But the transformation, either into joint-stock companies and trusts, or into State-ownership, does not do away with the capitalistic nature of the productive forces. In the joint-stock companies and trusts this is obvious. And the modern State, again, is only the organisation that bourgeois society takes on in order to support the external conditions of the capitalist mode of production against the encroachments, as well of the workers as of individual capitalists. The modern State, no matter what its form, is essentially a capitalistic machine, the state of the

capitalists, the ideal personification of the total national capital. The more it proceeds to the taking over of productive forces, the more does it actually become the national capitalist, the more the citizens does it exploit. The workers remain wage-workers—proletarians. The capitalist relation is not done away with. It is rather brought to a head. But, brought to a head, it topples over. State-ownership of the productive forces is not the solution of the conflict, but concealed within it are the technical conditions that form the elements of that solution.

This solution can only consist in the practical recognition of the social nature of the modern forces of production, and therefore in the harmonising the modes of production, appropriation, and exchange with the socialised character of the means of production. And this can only come about by society openly and directly taking possession of the productive forces which have outgrown all control except that of society as a whole. The social character of the means of production and of the products to-day reacts against the producers, periodically disrupts all production and exchange, acts only like a law of Nature working blindly, forcibly, destructively. But with the taking over by society of the productive forces, the social character of the means of production and of the products will be utilised by the producers with a perfect understanding of its nature, and instead of being a source of disturbance and periodical collapse, will become the most powerful lever of production itself.

Active social forces work exactly like natural forces: blindly, forcibly, destructively, so long as we do not understand, and reckon with, them. But when once we understand them, when once we grasp their action, their direction, their effects, it depends only upon ourselves to subject them more and more to our own will, and by means of them to reach our own ends. And this holds quite especially of the mighty productive forces of to-day. As long as we obstinately refuse to understand the nature and the character of these social means of action—and this understanding goes against the grain of the capitalist mode of production and its defenders—so long these forces are at work in spite of us, in opposition to us, so long they master us, as we have shown above in detail.

But when once their nature is understood, they can, in the hands of the producers working together, be transformed from master demons into willing servants. The difference is as that between the destructive force of electricity in the lightning of the storm, and electricity under

command in the telegraph and the voltaic arc; the difference between a conflagration, and fire working in the service of man. With this recognition at last of the real nature of the productive forces of to-day, the social anarchy of production gives place to a social regulation of production upon a definite plan, according to the needs of the community and of each individual. Then the capitalist mode of appropriation, in which the product enslaves first the producer and then the appropriator, is replaced by the mode of appropriation of the products that is based upon the nature of the modern means of production; upon the one hand, direct social appropriation, as means to the maintenance and extension of production—on the other, direct individual appropriation, as means of subsistence and of enjoyment.

Whilst the capitalist mode of production more and more completely transforms the great majority of the population into proletarians, it creates the power which, under penalty of its own destruction, is forced to accomplish this revolution. Whilst it forces on more and more the transformation of the vast means of production, already socialised, into State property, it shows itself the way to accomplishing this revolution. *The proletariat seizes political power and turns the means of production into State property.*

But, in doing this, it abolishes itself as proletariat, abolishes all class distinctions and class antagonisms, abolishes also the State as State. Society thus far, based upon class antagonisms, had need of the State. That is, of an organisation of the particular class which was *pro tempore* the exploiting class, an organisation for the purpose of preventing any interference from without with the existing conditions of production, and therefore, especially, for the purpose of forcibly keeping the exploited classses in the condition of oppression corresponding with the given mode of production (slavery, serfdom, wage-labour). The State was the official representative of society as a whole; the gathering of it together into a visible embodiment. But it was this only in so far as it was the State of that class which itself represented, for the time being, society as a whole; in ancient times, the State of slave-owning citizens; in the middle ages, the feudal lords; in our own time, the bourgeoisie. When at last it becomes the real representative of the whole of society, it renders itself unnecessary. As soon as there is no longer any social class to be held in subjection; as soon as class rule, and the individual struggle for existence based upon our present anarchy in production, with the collisions and excesses arising from these, are

removed, nothing more remains to be repressed, and a special repressive force, a State, is no longer necessary. The first act by virtue of which the State really constitutes itself the representative of the whole of society—the talking possession of the means of production in the name of society—this is, at the same time, its last independent act as a State. State interference in social relations becomes, in one domain after another, superfluous, and then dies out of itself; the government of persons is replaced by the administration of things, and by the conduct of processes of production. The State is not "abolished." *It dies out.* This gives the measure of the value of the phrase "a free State," both as to its justifiable use at times by agitators, and as to its ultimate scientific insufficiency; and also of the demands of the so-called anarchists for the abolition of the State out of hand.

Since the historical appearance of the capitalist mode of production, the appropriation by society of all the means of production has often been dreamed of, more or less vaguely, by individuals, as well as by sects, as the ideal of the future. But it could become possible, could become a historical necessity, only when the actual conditions for its realisation were there. Like every other social advance, it becomes practicable, not by men understanding that the existence of classes is in contradiction to justice, equality, etc., not by the mere willingness to abolish these classes, but by virtue of certain new economic conditions. The separation of society into an exploiting and an exploited class, a ruling and an oppressed class, was the necessary consequence of the deficient and restricted development of production in former times. So long as the total social labour only yields a produce which but slightly exceeds that barely necessary for the existence of all; so long, therefore, as labour engages all or almost all the time of the great majority of the members of society—so long, of necessity, this society is divided into classes. Side by side with the great majority, exclusively bond slaves to labour, arises a class freed from directly productive labour, which looks after the general affairs of society; the direction of labour, State business, law, science, art, etc. It is, therefore, the law of division of labour that lies at the basis of the division into classes. But this does not prevent this division into classes from being carried out by means of violence and robbery, trickery and fraud. It does not prevent the ruling class, once having the upper hand, from consolidating its power at the expense of the working-class, from turning their social leadership into an intensified exploitation of the masses.

But if, upon this showing, division into classes has a certain historical justification, it has this only for a given period, only under given social conditions. It was based upon the insufficiency of production. It will be swept away by the complete development of modern productive forces. And, in fact, the abolition of classes in society presupposes a degree of historical evolution, at which the existence, not simply of this or that particular ruling class, but of any ruling class at all, and, therefore, the existence of class distinction itself has become an obsolete anachronism. It presupposes, therefore, the development of production carried out to a degree at which appropriation of the means of production and of the products, and, with this, of political domination, of the monopoly of culture, and of intellectual leadership by a particular class of society, has become not only superfluous, but economically, politically, intellectually a hindrance to development.

This point is now reached. Their political and intellectual bankruptcy is scarcely any longer a secret to the bourgeoisie themselves. Their economic bankruptcy recurs regularly every ten years. In every crisis, society is suffocated beneath the weight of its own productive forces and products, which it cannot use, and stands helpless, face to face with the absurd contradiction that the producers have nothing to consume, because consumers are wanting. The expansive force of the means of production bursts the bonds that the capitalist mode of production had imposed upon them. Their deliverance from these bonds is the one pre-condition for an unbroken, constantly-accelerated development of the productive forces, and therewith for a practically unlimited increase of production itself. Nor is this all. The socialised appropriation of the means of production does away, not only with the present artificial restrictions upon production, but also with the positive waste and devastation of productive forces and products that are at the present time the inevitable concomitants of production, and that reach their height in the crises. Further, it sets free for the community at large a mass of means of production and of products, by doing away with the senseless extravagance of the ruling classes of to-day, and their political representatives. The possibility of securing for every member of society, by means of socialised production, an existence not only fully sufficient materially, and becoming day by day more full, but an existence guaranteeing to all the free development and exercise of their physical and mental faculties—this possibility is now for the first time here, but *it is here.*

With the seizing of the means of production by society, production of commodities is done away with, and, simultaneously, the mastery of the product over the producer. Anarchy in social production is replaced by systematic, definite organisation. The struggle for individual existence disappears. Then for the first time, man, in a certain sense, is finally marked off from the rest of the animal kingdom, and emerges from mere animal conditions of existence into really human ones. The whole sphere of the conditions of life which environ man, and which have hitherto ruled man, now comes under the dominion and control of man, who for the first time becomes the real, conscious lord of Nature, because he has now become master of his own social organisation. The laws of his own social action, hitherto standing face to face with man as laws of Nature foreign to, and dominating, him, will then be used with full understanding, and so mastered by him. Man's own social organisation, hitherto confronting him as a necessity imposed by Nature and history, now becomes the result of his own free action. The extraneous objective forces that have hitherto governed history, pass under the control of man himself. Only from that time will man himself, more and more consciously, make his own history—only from that time will the social causes set in movement by him have, in the main and in a constantly growing measure, the results intended by him. It is the ascent of man from the kingdom of necessity to the kingdom of freedom.

Let us briefly sum up our sketch of historical evolution.

I. Mediæval Society.—Individual production on a small scale. Means of production adapted for individual use; hence primitive, ungainly, petty, dwarfed in action. Production for immediate consumption, either of the producer himself or of his feudal lord. Only where an excess of production over this consumption occurs is such excess offered for sale, enters into exchange. Production of commodities, therefore, only in its infancy. But already it contains within itself, in embryo, *anarchy in the production of society at large.*

II. Capitalist Revolution.—Transformation of industry, at first by means of simple co-operation and manufacture. Concentration of the means of production, hitherto scattered, into great workshops. As a consequence, their transformation from individual to social means of production—a transformation which does not, on the whole, affect the form of exchange. The old forms of appropriation remain in force. The capitalist appears. In his capacity as owner of the means of production, he also appropriates the products and turns them into com-

modities. Production has become a *social* act. Exchange and appropriation continue to be *individual* acts, the acts of individuals. *The social product is appropriated by the individual capitalist.* Fundamental contradiction, whence arise all the contradictions in which our present day society moves, and which modern industry brings to light.

A. Severance of the producer from the means of production. Condemnation of the worker to wage-labour for life. *Antagonism between the proletariat and the bourgeoisie.*

B. Growing predominance and increasing effectiveness of the laws governing the production of commodities. Unbridled competition. *Contradiction between socialised organisation in the individual factory and social anarchy in production as a whole.*

C. On the one hand, perfecting of machinery, made by competition compulsory for each individual manufacturer, and complemented by a constantly growing displacement of labourers. *Industrial reserve-army.* On the other hand, unlimited extension of production, also compulsory under competition, for every manufacturer. On both sides, unheard of development of productive forces, excess of supply over demand, over-production, glutting of the markets, crises every ten years, the vicious circle: excess here, of means of production and products—excess there, of labourers, without employment and without means of existence. But these two levers of production and of social well-being are unable to work together, because the capitalist form of production prevents the productive forces from working and the products from circulating, unless they are first turned into capital—which their very superabundance prevents. The contradiction has grown into an absurdity. *The mode of production rises in rebellion against the form of exchange.* The bourgeoisie are convicted of incapacity further to manage their own social productive forces.

D. Partial recognition of the social character of the productive forces forced upon the capitalists themselves. Taking over of the great institutions for production and communication, first by joint-stock companies, later on by trusts, then by the State. The bourgeoisie demonstrated to be a superfluous class. All its social functions are now performed by salaried employees.

III. Proletarian Revolution.—Solution of the contradictions. The proletariat seizes the public power, and by means of this transforms the socialised means of production, slipping from the hands of the bourgeoisie, into public property. By this act, the proletariat frees the

means of production from the character of capital they have thus far borne, and gives their socialised character complete freedom to work itself out. Socialised production upon a pre-determined plan becomes henceforth possible. The development of production makes the existence of different classes of society thenceforth an anachronism. In proportion as anarchy in social production vanishes, the political authority of the State dies out. Man, at last the master of his own form of social organisation, becomes at the same time the lord over Nature, his own master—free.

To accomplish this act of universal emancipation is the historical mission of the modern proletariat. To thoroughly comprehend the historical conditions and thus the very nature of this act, to impart to the now oppressed proletarian class a full knowledge of the conditions and of the meaning of the momentous act it is called upon to accomplish, this is the task of the theoretical expression of the proletarian movement, scientific Socialism.

## INTERSTATE COMMERCE COMMISSION

As a result of the report of the special Senate committee on Interstate Commerce, the Interstate Commerce Act was passed February 4, 1887. The considerations that led to its passage are given below in the committee's report. The main provisions of the act are these:—

The act applies to interstate transportation only; it decrees that charges must be reasonable; that there shall be no unjust discrimination between shippers, in charges or service; nor between connecting lines; a common carrier cannot receive any greater compensation in the aggregate, under substantially similar circumstances for a shorter than longer distance over the same line in the same direction; pooling is made unlawful; schedules and charges must be posted, and ten days' notice given of an advance, three days of a reduction in rates; an interstate commerce commission of five commissioners, appointed by the President, is established; this may sit as a court to hear complaints, and its decisions and finding of fact shall be taken as *prima facie* evidence; officers may be compelled to testify, but their evidence shall not be used against

them in any criminal proceedings. In case of disobedience United States courts may be petitioned.

## THE PUBLIC CONTROL OF RAILROADS

The introduction of the railroad brought into the world an untried and powerful force, the possibilities of which are even yet but imperfectly understood, and its operation brought important questions which of necessity were met and decided blindly, without the advantage of precedent or experience, and without any adequate appreciation of the unforeseen and manifold changes that have since resulted through its agency. During what may be termed the era of construction the chief consideration that influenced the people and the legislatures of Great Britain and America was how to secure railroads, not how to control them. It was many years before the necessity of control became apparent or the matters over which control was needed became understood. The construction of railroads was at first authorized by special charters. When the first charters were granted it was supposed that the railroad would be merely a modification of or an improvement upon the public highway; that it would simply furnish a line of communication open to all, like a canal, and that it could be used at pleasure, as a water route it used, by all who might be disposed to place upon it means of carriage. It was also supposed that the railroad would be used only for the carriage of passengers, and not for the transportation of freight, except perhaps to a limited extent. How thoroughly this misconception prevailed is illustrated by a report made to the New York legislature as late as 1835, in which the four leading engineers of that state expressed the following remarkable opinion:

> The railroads admit of advantageous use in districts where canals, for the want of water, would be impracticable. They will probably be preferred where high velocities are required, and for the transportation of passengers, and, *under some circumstances, for the conveyance of light goods.*

The supposed analogy between the railroad and the public highway in their relations to the community gave direction to the earlier legislation of England and the United States. And even when the discovery was made that there was an element of monopoly inseparably connected with the business of transportation by rail, the earlier efforts at regula-

tion were directed at the limitation of the profits of the corporation rather than towards the protection of the shipper.

The widely varying methods which have been adopted by different Governments in dealing with the problems of railway development and regulation may be grouped as follows:

1. The policy of private ownership and private management—

(*a*) Without interference or supervision by the Government.

(*b*) Subject to compulsory and penal legislation for control and regulation of rates.

(*c*) Subject to investigation by a commission with advisory powers, and depending largely upon public opinion for the enforcement of its recommendations.

(*d*) Subject to investigation by a commission with power to fix and regulate rates.

2. Exclusive State ownership and Government management.

3. State ownership and private management under Government supervision and control.

4. Partial State ownership and management in competition with private ownership and management.

Regulation through state ownership has been practically unknown in the United States. It is of foreign origin and is foreign to the character of our institutions. The time may come when the people of the United States will be forced to consider the advisability of placing the railways of the country completely under the control of the General Government, as the postal service is, and as many believe the telegraph service should be. This would seem to be the surest method of securing the highest perfect and the greatest efficiency of the railroad system in its entirety, and the best method of making it an harmonious whole in its operation and of bringing about that uniformity and stability of rates which is the greatest need of trade and commerce. But the dangers to be apprehended from the giving of such vast additional power to the Government will always prove a formidable barrier to the adoption of such a policy, and this committee sees no necessity for considering its advantages or disadvantages until other methods of regulation more American in spirit have at least been given a trial and have proved unsatisfactory. Nor is it deemed important to investigate in detail the experience of those European nations in which the policy of State ownership or management in one form or another has prevailed.

In those nations the railroad question has presented itself under different conditions, and has admitted of methods of regulation wholly impracticable in the United States, by reason of the marked differences in the organization of the machinery of government and in the customs,

temper, and habits of thought of the people. The English railroad system, however, has grown up under conditions more nearly resembling those prevailing upon this side of the Atlantic than those existing in any other country. It has been developed under the operation of the principle of private ownership and management, subject to Parliamentary control, and substantially all of the methods of regulation proposed in this country had first been tested there. The English people early undertook the legislative regulation of their railroads. They have been considerably in advance of us in dealing with the difficulties that have been encountered, and have given the subject no little attention.

For these reasons the experience of England is of more interest and value to us than that of those nations in which the policy of state ownership has been more or less generally adopted, and these reasons seem to warrant a glance at the efforts which have been made in that country for more than fifty years to unravel the complications of the railroad question, and to hit upon a satisfactory method of enforcing the performance of public obligations and of adjusting the relations between the railroads and the people. The information on these subjects herewith submitted is based largely upon the statements contained in the numerous reports which have been made by Parliamentary committees.

### THE COURSE OF RAILROAD LEGISLATION IN ENGLAND—WORKINGS OF THE ENGLISH COMMISSION—THE PRESENT STATUS OF AFFAIRS

When railroad construction began in England that country already had quite a complete system of canals, with which the new methods of transportation came immediately into active competition. By the charters first granted the railroads were required to admit to their lines the cars and locomotives of other companies and individuals, and the acts usually prescribed the maximum tolls to be charged for such service. These were regulations which it had been found necessary to apply tc the canals, in the management of which abuses had been complained of somewhat similar to those that afterwards characterized the management of railways. Competition between the different carriers who were expected to use the route was relied on to secure to the public needful facilities and fair rates under these provisions. But this was not the result, and within ten years after the opening of the first railway it was generally recognized that a railroad must be to some extent a monopoly, because the service to be performed was of such a nature that the high-

est degree of efficiency would be attained and the convenience of the public would be best subserved by committing the work to but one carrier. It is worthy of remark that even at that early period in railroad history the future direction of the development of the system was clearly foreseen by at least one man.

In the words of Mr. Sterne:

I have in hand a speech delivered in the House of Commons by Mr. James Morrison on the 17th of May, 1836. Mr. Morrison was the A. T. Stewart of England, and died leaving a fortune of four or five million pounds sterling. He was a member of Parliament, and he told his associates, as early as 1836, that their maximum rates would be of no value, that the economies of railway transportation from decade to decade, and the improvement of railway transportation and the development of railway traffic, would make their maximum rates ridiculously high, and would be an excuse for extortion in individual instances. Indeed, the clear understanding which he had of the railway problem, as early as 1836, was absolutely marvelous. But no attention was paid to his recommendation; it was voted down. They recognize now, however, that Mr. Morrison was one of the few men who then foresaw the railway problems of the present as they are now developing.

The new questions raised by this discovery of the element of monopoly in railroad transportation were considered by a Parliamentary committee, of which Sir Robert Peel was a member, and which reported in 1840 that the method of competition which has been described was impracticable; that monopoly upon each line was inevitable, that a single management of each railway was expedient, and that these changed conditions made necessary the protection of the public interests, for the reason "that the interest of the companies was, to a certain extent only, that of the public." At the same time the committee expressed the belief that "an enlightened view of their own interests would always compel managers of railroads to have due regard to the general advantage of the public."

It was supposed that the principles of free trade would apply in the construction and operation of railroads, and it was quite naturally expected that this business would be subject to the same natural laws of competition that governed and regulated other commercial enterprises and operations.

While these theories held sway parallel lines were looked to as an effective means of regulation. Parliament encouraged the building of competing lines, and this policy brought on a period of great activity in railroad construction and speculation. But the effects of competition between different lines were not what had been anticipated, and attracted

so much attention that in 1844 another committee, headed by Mr. Gladstone, was appointed, which took under consideration the question of competition and management, and submitted in all five reports. The second report recommended the appointment by Parliament of private bill committees to examine into the propriety of proposed competing schemes, and the third expressed the following conclusions:

That the indefinite concessions made to the earlier companies had become unnecessary; that competition between railways would do more harm to the companies than good to the public; that the effect of monopoly upon the public directly and upon the railways indirectly ought to be guarded against, and that in authorizing new lines Parliament should reserve certain powers to be exercised after a time.

The idea of state ownership as an effective means of regulation captivated this committee, which became convinced that the people must in one way or another pay for whatever transportation facilities they enjoyed, and that the main question was how to secure by legislation "the greatest amount of accommodation at the least cost." And the general conclusion reached by the committee in its final report was that regulation was to be depended upon rather than competition. These reports led to the passage in 1844 of a law looking to the ultimate acquisition of the railways by the Government, and prescribing the terms of their purchase at the expiration of twenty-one years should that policy be decided upon.

During this interval another unexpected characteristic of railway management came prominently into notice. The addition of too many competing lines developed a tendency toward amalgamation, and verified George Stephenson's axiomatic statement that "Where combination is possible, competition is impossible." Accordingly, in a report made by the Board of Trade of the United Kingdom relative to the numerous amalgamations proposed in 1845, it was recommended that amalgamations should not be permitted by Parliament when the purpose was to avoid competition, but only between branches and main lines or when continuous lines were formed, and then only after due consideration.

Another committee, appointed in 1846, discovered that where amalgamations had not been authorized the roads often reached the same end through private working arrangements, some of which virtually amounted to consolidation, and that they avoided competition wherever practicable. On the recommendation of this committee that it was necessary to establish a department of the Government to take "supervision of the railways and canals, with full power to enforce such

regulations as may from time to time appear indispensable for the accommodation and general interests of the public," the railway commission was created, but was only allowed to exist until 1851, when its duties were transferred to the Board of Trade. Meantime the efforts at amalgamation grew more and more determined, and the process went on by the consent of Parliament, notwithstanding all the restrictions imposed upon it, and despite the growing public dread of its effects.

Still another committee inquired into this vexed question of amalgamation, and its elaborate reports upon the subject brought about the passage of the "canal and railway traffic act" of 1854, usually known as the Cardwell act, which has been the model of much of our State legislation against unjust discrimination. The purpose of the act was to prevent undue preferences, and to compel interchange of traffic between railways and between railways and canals upon equal terms. This act established two important principles that have since been generally followed. One was that every company should be compelled to afford the public the full advantages of the convenient interchange of traffic from one line to another. The second was that the companies were under obligations to and should be required to make equal rates to all under the same circumstances.

The time when the state could take possession of the roads came in 1865, and a royal commission was appointed, which gathered a great deal of evidence and went into the questions presented quite fully. The most important conclusions of the commission have been summarized as follows:

That it is not expedient for the Government to avail itself of its reserved right to purchase railways.

That Parliament should not interfere with the incorporation and financial affairs of railway companies, leaving such matters to be dealt with, under the "joint stock companies act," limiting its own action to regulating the construction of the lines and the relations between the public and the companies so incorporated.

That railway companies should be bound to run at least two trains a day for third-class passengers.

That it would be "inexpedient, even if it were practicable, to adopt any legislation which would abolish the freedom which railway companies enjoy of charging what sum they deem expedient within their maximum rates, when properly defined, limited as that freedom is by the traffic act."

That railway companies should be required to make stated reports to the Board of Trade in such form as the board may require.

Finally in 1872, a joint select committee was appointed and made a most thorough investigation of the railroad question. The report of this

committee passed in review the history of England's legislation during its experience of forty years. It was shown that little had been accomplished, although thirty-three hundred acts had been passed and an expenditure of some £80,000,000 had been imposed upon the companies. It was also shown that the process of amalgamation had gone on with little regard to the recommendations of committees, commissions, and Government departments, and the result was that "while committees and commissions carefully chosen have, for the last thirty years, clung to one form of competition after another, it has, nevertheless, become more and more evident that competition must fail to do for railways what it does for ordinary trade; and that no means have yet been devised by which competition can be permanently maintained." Nor did the committee see any reason "to suppose that the progress of combination has ceased, or that it will cease until Great Britain is divided between a small number of great companies." At the same time, however, the committee made it evident that in the past amalgamation "had not brought with it the evils that were anticipated, but that in any event long and varied experience had fully demonstrated the fact that while Parliament might hinder and thwart, it could not prevent it, and it was equally powerless to lay down any general rules determining its limits or character."

Other important conclusions were reached by the committee as follows:

That competition between railways existed only to a limited extent and could not be maintained by legislation.

That combination was increasing and likely to increase.

That competition by sea should be secured by preventing railway companies from getting control over public harbors.

That canals were of advantage in securing competition; that their facilities for through shipments should be increased, and that no canal should be placed directly or indirectly under the control of any railway company.

That a system of equal mileage rates, or charges in proportion to distance, was inexpedient and impracticable for the following reasons:

(*a*) It would prevent railway companies from lowering their fares and rates, so as to compete with traffic by sea, by canal, or by shorter or otherwise cheaper railways, and would thus deprive the public of the benefit of competition, and the company of a legitimate source of profit.

(*b*) It would prevent railway companies from making perfectly fair arrangements for carrying at a lower rate than usual goods brought in larger and constant quantities, or for carrying for long distances at a lower rate than for short distances.

(*c*) It would compel a company to carry for the same rate over a

line which has been very expensive in construction, or which, from gradients or otherwise, is very expensive in working, at the same rate at which it carries over less expensive lines.

In short, to impose equal mileage on the companies would be to deprive the public of the benefit of much of the competition which now exists, or has existed, to raise the charges on the public in many cases where the companies now find it to their interest to lower them, and to perpetuate monopolies in carriage, trade, and manufacture in favor of those rates and places which are nearest or least expensive, where the varying charges of the companies now create competition. And it will be found that the supporters of equal mileage, when pressed, often really mean, not that the rates that they pay themselves are too high, but that the rates that others pay are too low.

Pressed by these difficulties, the proposers of equal mileage have admitted that there must be numerous exceptions, *e. g.*, where there is sea competition (*i. e.*, at about three-fifths of the railway stations of the United Kingdom), where low rates for long distances will bring a profit, or where the article carried at low rates is a necessary, such as coal. It is scarcely necessary to observe that such exceptions as these, while inadequate to meet all the various cases, destroy the value of "equal mileage" as a principle, or the possibility of applying it as a general rule.

That the fixing of legal rates based upon the actual cost of the railways and calculated to yield only a fair return upon such cost was impracticable.

That the plan of maximum charges had been a failure, and that such rates afforded little real protection to the public, since they were always fixed so high that sooner or later it became the interest of the companies to carry at lower rates.

That there should be publicity of rates and tolls.

That the new tribunal was needed to take supervision of the transportation interests of the Kingdom, and with authority to enforce the laws relating to railways and canals, to hear complaints and adjust differences, and to advise Parliament upon questions of railway legislation.

This investigation, by making plain the lessons taught by many years of experience, was especially valuable in at least bringing about a general recognition of the fact that the relations between the railways and the community require special treatment and cannot be defined or governed in accordance with the natural laws regulating ordinary commercial intercourse. It was evident that the policy adopted by the committee, if followed out to its conclusion, might lead in time to a few great corporations obtaining an absolute monopoly of the business of transportation by rail throughout the entire Kingdom, and even to finally placing the control of these most important interests in the hands of a small number of individuals, whose powers might become greater than those of the Government itself. Nevertheless, without being able to indicate how the relations between the Government and these great monopolies would or should ultimately be adjusted, the com-

mittee did not appear to believe that the time was ripe to check the development of the railway system of Great Britain by extreme measures, and was content to recommend the establishment of a special tribunal as the first step to be taken in inaugurating the policy of special treatment which it had become apparent must be adopted to meet the exigencies of the situation.

This recommendation was complied with by the creation of what is known as the railway commission of 1873, which was at first given a tenure of but five years, but which has since been continued. This tribunal is chiefly judicial in character; it is, in fact, a separate railway court, composed of three commissioners or judges, and has jurisdiction over all matters in relation to the interchange of traffic, and to all contracts between railway companies, as well as complaints of undue preference and of other violations of railway laws. The most recent official declaration concerning this commission is found in the report of the select committee of twenty-seven members, appointed by the House of Commons, in 1882, to inquire into its working and the rates charged by railways and canals. After an investigation, lasting several months, this committee reported that the tribunal should be made permanent as well as special, and say:

The railway commission has, to a great extent, been hindered in its work by the temporary character with which it has hitherto been invested. At the same time your committee are convinced that the establishment of the commission has been of great public advantage, not merely in causing justice to be speedily done in those cases which have been brought before it, but also in preventing differences from arising as between railway companies and the public. Its utility is not to be measured solely by the instances in which it has been called upon to "hear and determine," but also by the deterrent and controlling influence of its existence.

Representatives of the railway companies, backed up by legal gentlemen of eminence, have urged upon your committee that it is not desirable to continue the special tribunal in its present form, but that the court should be reconstituted by the appointment of a single judge, to be selected from the bench or the bar, aided by assessors wherever other than legal knowledge is required. From the traders and the general public, on the other hand, no demand has come for such a change; on the contrary, the general tenor of their evidence exhibits satisfaction with the services rendered to the public by the existing railway commission.

Accordingly the committee recommended:

That the railway commission be made permanent, and a court of record.

That the powers and jurisdiction of the railway commission be extended to cover—

(*a*) All questions arising under the special acts or the public statutes for regulating railway or canal traffic affecting passengers or goods.

(*b*) The making of orders which may necessitate the co-operation of two or more railway or canal companies within the statutory obligations of the companies.

(*c*) Power to order through rates on the application of traders, but no such order to impose on a railway company a rate lower than the lowest rate of such railway company for similar articles under similar circumstances.

(*d*) The revision of traffic agreements both of railways and canals, in as large a measure as the powers formerly exercised by the Board of Trade.

(*e*) The granting of damages and redress for illegal charges and undue preferences.

(*f*) The commissioners to have power, on the joint application of parties, to act as referees in rating appeals.

That the railway commissioners should deliver separate judgments when not unanimous.

One appeal to be granted as of right from the judgments of the commission, and "prohibition" as well as "*certiorari*" to be forbidden.

In conclusion, the committee "report that on the whole of the evidence they acquit the railway companies of any grave dereliction of their duty to the public. It is remarkable that no witnesses have appeared to complain of 'preferences' given to individuals by railway companies as acts of private favor or partiality, such as were more or less frequent during the years immediately preceding the act of 1854. Your committee find that the rates for merchandise on the railways of the United Kingdom are, in the main, considerably below the maxima authorized by Parliament, although these charges appear to be higher for the longer distances than on many continental lines. But on the other hand, the service of our home railways is performed much more rapidly than on the continent."

For later and more complete information concerning the English Railway Commission than could elsewhere be obtained the committee is indebted to the recently published work on "Railroad Transportation," by Mr. Arthur T. Hadley, of New Haven, who has made a very careful study of the English railway system and legislation. The results of his investigations are herewith presented in condensed form. He states the general situation as to legislation in the following paragraphs:

With the act of 1873 the general railroad legislation may be said to have closed. The movements which the public had feared for thirty years had now pretty much expended their force. Amalgamations

which were confidently expected in 1872 did not take place after all. Joint-purse arrangements became less important instead of more important, because railroads found that they could maintain rates without them.

It is not exactly true to say that "in Great Britain the discussion of the railroad problem may be considered as over for the time being." The railroad problem has ceased to be a bugbear; but it has become all the more a question for practical discussion. Vague fears with regard to the growth of the railway power have given place to pointed complaints as to its abuse in individual instances. The period of general legislation has passed. Mr. Adams is right in saying, "As a result of forty years of experiment and agitation Great Britain has on this head come back very nearly to its point of commencement." He is not quite right in adding, "It has settled down on the doctrine of *laissez-faire.*" It might better be said that it has settled down on the policy of specific laws for specific troubles.

After briefly mentioning the three experiments in the line of railway commissions attempted in England, in 1840, 1844, and 1846, Mr. Hadley says:

We have seen what were the events which led to the passage of the regulation of railways act in 1873. The commission appointed under that act was to consist of three members; one of them a railroad man, one a lawyer. They received a salary of £3,000 each. They were to decide all questions arising under the act of 1854, and subsequent acts connected with it. They were further empowered to arbitrate between railroads in a variety of cases; to compel companies to make through rates which should conform to the intention of the act of 1854; to secure publicity of rates; to decide what constitutes a proper terminal charge, and some other less important matters. On questions of fact their decision was to be final; on questions of law it was to be subject to appeal. The railway commissioners themselves were to determine what were questions of fact and what were questions of law. Subsequent acts have made but slight changes in these powers.

The commission consisted of able men—Sir Frederick Peel, Mr. Price, formerly of the Midland Railway, and Mr. Macnamara; the last-named died in 1877, and was succeeded by Mr. A. E. Miller. They went to work with energy, and in a spirit which promised to make the experiment a signal success. And it was at first supposed to be such a success. People judged by the reports of the commission itself; and they were the more prone to believe these reports because it was so desirable to find an easy solution of perplexing questions of railroad policy. Mr. Adams, writing in 1878, said, "The mere fact that the tribunal is there; that a machinery does exist for the prompt and final decision of that class of questions, puts an end to them. They no longer exist." That represented the general public opinion on the subject at the time; it represents the general impression in America down to the present time.

In 1878, the very year when Mr. Adams wrote, the original term of the commission expired. People supposed that it would be made

permanent. Instead of that the renewals have been for much shorter periods, leaving the commissioners a precarious tenure, and showing dissatisfaction somewhere.

A Parliamentary investigation on railroad rates in 1881-'82 showed the grounds of dissatisfaction only too clearly. The testimony revealed a state of things almost unsuspected by the general public, and giving an entirely different explanation of the fact that the commissioners had so few cases to deal with. The substance is that the power of the commission satisfies nobody. It has power enough to annoy the railroads, and not power enough to help the public efficiently.

The railway commission was a court, not an executive body, but to all intents and purposes a court of law. And in establishing this new court, in addition to those already existing, Parliament had two ends in view: (1) To have a tribunal which would and could act when others would or could not. (2) To avoid the expense, delay, and vexation incident to litigation under the old system. Neither end was well fulfilled.

(1) The commission could not act, partly from want of jurisdiction, partly from want of executive power. Its jurisdiction did not cover by any means the whole ground. The provisions about terminals, arbitration, working agreements, etc., amounted to very little. Its real power was under the act of 1854. It could under this act require companies to furnish "proper facilities," and it could prevent their giving "preferences." But it could *not* compel a company to comply with special acts or special provisions of its charter. This is a serious difficulty, because the question of proper facilities was closely connected with charter requirements, and the railroad could almost anywhere raise the point of want of jurisdiction.

Nor could it enforce its decrees. Passive resistance of the railroads and jealousy on the part of the old established courts combined to produce this effect. For instance, under the act of 1854, if the railways refused to comply with the decisions of the court of common pleas, they were liable to a fine of $1,000 for every day's delay. The London, Chatham and Dover Railway refused to comply with one of the commission's decisions, and claimed that they were not liable to any such fine, although all the powers of the court of common pleas, under the act of 1854, had been transferred to the railway commission by the act of 1873. The court of exchequer actually sustained the railroad; and it was not until 1878 that by a decision of the Queen's bench the railway commission really had the power to do anything if a company chose to disregard its orders.

The injunctions of the commission, at best, only affect the future; for any remedy for the past there must be a new complaint and trial before a regular court. And so it often happens that a railroad, after exhausting all its means of resistance, obeys the decisions of the commission in reference to one particular station, without taking any notice of it at other stations where the same principle is involved. Thus, in the case of the manure traffic of Aberdeen, after long litigation, the rate was decided to be illegal. The railroad then reduced its Aberdeen rates, but continued its old schedule of charges at other points on its route

where there were not organized interests strong enough to make a fight.

On the face of the act of 1873 the decisions of the commission, as to what were questions of fact or questions of law, appeared to be final. But by writ of mandamus from a court of appeal the decision on this point could be at once taken out of the hands of the commission by compelling them "to state a case," which could then be made the subject of action in the higher court. So this important power was made of no effect.

(2) Complaints before the commission are not quite so slow or costly as they were before the courts, but they are bad enough to prevent most men from undertaking them. Sir Frederick Peel himself admits that the expense frightens people away from making complaints. But this is by no means the worst. The testimony before the Parliamentary committee of 1881-'82 is full of matter to startle those who argue that because there are few complaints before the commission there are few men that have grievances. Men have good reason to think twice before they enter a complaint.

In the Aberdeen manure case, already referred to, the Aberdeen men, successful at every point, lost more money than they gained. Every important case is so persistently appealed that the original promptness or cheapness of railway commission practice counts for nothing. But the indirect results are yet worse. A complainant is a marked man, and the commission cannot protect him against the vengeance of the railroads. A town fares no better. It complains of high terminal charges, and the company retorts by raising the local tariff for that place 100 per cent. A coal mine complains of freight rates, and the company refuses to carry for it on any terms; it has ceased, it says, to be a common carrier of coal. Even the war department is afraid. It has grievances, but it dare not make them public for fear of reprisals. "It is quite clear," says the secretary of the Board of Trade, "that it is a very formidable thing to fight a railway company."

It is not easy to see what can be done in the face of these difficulties, so different from anything which we see in most American States. Our commissioners, with fewer powers, have infinitely more power. The reason is, that in America to defy such an authority involves untold dangers, public sentiment being irritable and unrestrained, whereas in England it involves no danger at all, public sentiment being long-suffering and conservative.

The lawyers say, strengthen the legal element in the commission. Some of the railroad men say so too, because they think that a commission formed on the model of the old courts would interfere no more than the old courts. On the other hand, many men desire the appointment of a public prosecutor to relieve individuals of the danger and odium of bringing complaints, or that chambers of commerce may be allowed to undertake such prosecutions. Others go still further and urge that the powers of the commission be increased, and that they be allowed to determine on general grounds what constitutes a reasonable rate. The commission itself would be glad to do that, but such a thing, however cautiously carried out, would involve the granger principle of fixing rates. It seems unlikely that Parliament will make any of these

proposed changes, except to give chambers of commerce the right to prefer charges.

We have dwelt on the dark side of the picture, because there is a general impression in this country that the English railway commission is a complete success. It must not be inferred that it is a complete failure. It has in the first nine years of its existence passed judgment on one hundred and ten cases. Only seventeen of these have been appealed, and in eleven of them the commissioners have been sustained. The decisions have, as a rule, been marked by good sense and impartiality. The direct good to the complainants may have been small, but the indirect good to the public was, doubtless, great. The commission has made serious and generally successful efforts to enforce a law in cases where it would otherwise have been a dead letter. These particular cases may have given more trouble than they were worth. But the very existence of such a power constitutes a check upon arbitrary action in general. We cannot assume, as many do, that the few complaints preferred before the commission represent anything like the amount of well-founded grievances. But we can assume that the chance for such complaints to be made and heeded makes the railroad managers more cautious in giving occasion for them. Although no one is fully satisfied with what the commission has done, the great majority of shippers are obviously of the opinion that it has prevented much evil which would otherwise have gone unchecked.

In concluding his sketch of the English railroad legislation, Mr. Hadley shows that the system of special rates to develop business has grown up in the same way as in America; that the chief source of public complaint is not extortionate rates, but different rates; that the low through rates are occasioned by the competition of water routes, which has existed at three-fifths of the stations in the United Kingdom; that the railroads have been obtaining control of the canals, and even of the open water routes in some cases, by securing possession of the landing places and harbor facilities, but are unable to control the water routes between London and foreign countries; that while the courts have succeeded in almost entirely stopping discriminations between individuals, personal favoritism, and the payment of rebates, the discriminations against localities and certain lines of business have become more conspicuous; and he sums up the present state of things, as follows:

(1) The roads may make what special rates they please; but if they make a rate to one man they must extend the same privilege to all others in like circumstances. If they have been secretly paying rebates to one shipper, they may be compelled to refund to any other shipper similarly placed the same rebates on all his shipments since the special contract with the one shipper began.

(2) It is held by the railway commissioners that two shippers are similarly placed and must be similarly treated when the cost to the railroad of handling the goods for one is the same as for the other; and, conversely, unless some special reason can be shown, the railroad has no

right to put a less favorably situated shipper on an equality with a more favorably situated one.

(3) But the last Parliamentary committee has refused to indorse these principles, and has said that a preference is not unjust so long as it is the natural result of fair competition.

THE NECESSITY OF NATIONAL REGULATION OF INTERSTATE COMMERCE

The two propositions which the committee has kept prominently in view throughout the entire investigation have been whether any legislation for the regulation of interstate transportation is necessary or expedient, and, if so, in what manner can the public interest be best subserved by legislation on that subject.

The consideration of the first proposition may seem to be a work of supererogation, for it is the deliberate judgment of the committee that upon no public question are the people so nearly unanimous as upon the proposition that Congress should undertake in some way the regulation of interstate commerce. Omitting those who speak for the railroad interests, there is practically no difference of opinion as to the necessity and importance of such action by Congress, and this is fully substantiated by the testimony accompanying this report, which is a fair concensus of public sentiment upon the question. The committee has found among the leading representatives of the railroad interests an increasing readiness to accept the aid of Congress in working out the solution of the railroad problem which has obstinately baffled all their efforts, and not a few of the ablest railroad men in the country seem disposed to look to the intervention of Congress as promising to afford the best means of ultimately securing a more equitable and satisfactory adjustment of the relations of the transportation interests to the community than they themselves have been able to bring about.

The evidence upon this point is so conclusive that the committee has no hesitation in declaring that prompt action by Congress upon this important subject is almost unanimously demanded by public sentiment.

This demand is occasioned by the existence of acknowledged evils incident to and growing out of the complicated business of transportation as now conducted, evils which the people believe can be checked and mitigated, if not wholly remedied, by appropriate legislation. The committee recognizes the justice of this demand, and believes that action by Congress looking to the regulation of interstate transportation is necessary and expedient, for the following reasons:

1. The public interest demands regulation of the business of

transportation because, in the absence of such regulation, the carrier is practically and actually the sole and final arbiter upon all disputed questions that arise between shipper and carrier as to whether rates are reasonable or unjust discrimination has been practiced.

It is argued by railroad representatives that arbitrary or oppressive rates cannot be maintained; that they are adjusted and sufficiently regulated by competition with rival roads and with water routes, by commercial necessities, by the natural laws of trade, and by that self-interest which compels the corporations to have due regard to the wants and the opinions of those upon whom they must depend for business; that such discriminations as exist are for the most part unavoidable; that the owners and managers of the property are the best judges of the conditions and circumstances that affect the cost of transportation and should determine the compensation they are entitled to receive; and that, in any event, the common law affords the shipper an adequate remedy and protection against abuse or any infringement of his rights.

This answer fails to recognize the public nature and obligations of the carrier, and the right of the people, through the Governmental authority, to have a voice in the management of a corporation which performs a public function. Nor do the facts warrant the claim that competition and self-interest can be relied upon to secure the shipper against abuse and unjust discrimination, or that he has an available and satisfactory remedy at common law.

If it is found that the common law and the courts do not, in fact, afford to the shipper an effective remedy for his grievances, we have no need to inquire to what extent grievances may exist. The complicated nature of countless transactions incident to the business of transportation make it inevitable that disagreements should arise between the parties in interest, and it is neither just nor proper that disputed questions materially affecting the business operations of a shipper should be left to the final determination of those representing an opposing financial interest. When such disagreements occur the shipper and the carrier are alike entitled to a fair and impartial determination of the matters at issue, and by all the principles governing judicial proceedings the most fair-minded railroad official is disqualified by his personal interest in the result from giving such a determination. If, however, there existed an impartial tribunal to which the shipper could readily appeal, he would find less occasion for appealing from the decision of the carrier, and the differences between shipper and carrier would be more likely to be adjusted amicably without such an appeal.

The simple fact that the shipper is now obliged to submit to the adjudication of his complaint by the other party in interest, the party by whom he supposes himself to have been aggrieved, is in itself sufficient to demonstrate the necessity of such legislation as will secure to the shipper that impartial hearing of his complaints to which he is entitled by all the recognized principles of justice and equity.

Evidence is not wanting to prove that the remedy at common law is impracticable and of little advantage to the ordinary shipper. It has been found so by the people of the States in dealing with their local traffic, and, as has been shown, their recognition of the fact has been authoritatively recorded in nearly every State in the Union by statutory enactments, and in many of them by the establishment of commissions, in the effort to provide for the shipper that prompt and effective remedy which it has been found by experience that recourse to the common law has failed to afford. The reasons for this failure apply with even greater force to the more complicated transactions of interstate commerce than to State traffic, because the former involve more perplexing questions and are affected by a greater diversity of varying conditions. The legislation of the States, the reports of the State commissions, the records of the courts, the evidence of shippers, and, in short, the whole current of testimony, is to the same effect; and the fact stated is also admitted by some of the highest railroad authorities. Mr. Fink says:

> In many cases where small amounts are involved, which do not justify legal proceedings against the company, the aggrieved parties are prevented from prosecuting their claims. * * * Ordinary courts are not properly constituted for that purpose, and the time required for the adjudication of claims is so long and the expense so great as to defeat the very object for which proceedings are instituted.

Leaving out of consideration the natural disinclination of the average shipper to engage in litigation with a corporation which may have the power to determine his success or failure in business, and to enter the lists against an adversary with ample resources and the best legal talent at its command and able to wear out an opponent by the tedious delays of the law, it is plain that the shipper is still at a great disadvantage in seeking redress for grievances under the common law, which places upon the complainant the burden of proof and requires him to affirmatively establish the unreasonableness of a given rate or the fact of an alleged discrimination. What such an undertaking practically involves is indicated by the following extract from the statement of Mr. Kernan, the chairman of the New York commission, which sums up the whole case:

Assuredly there have been and do exist unreasonable rates and unjust discriminations. This much will be admitted by all; it will not be denied even by any carrier. Why, then, have not the courts enjoined the continuance of the wrongs and enforced the payment of damages? Why, again, is it that substantially no suits ever have been brought and that so few decisions in this country exist? It is not because of defects in the law or in the constitution of the courts, but it is because the subject is one which neither client nor lawyer, judge nor jury, can unravel or deal with intelligently within the compass of an ordinary trial and with such knowledge of the matter as men generally well educated possess. Let a man take the testimony in five volumes before the Hepburn committee; read one hundred pages of the clear and able statements of Mr. Blanchard, for instance; con over the facts and figures he gives, and then let him try to reach a conclusion upon the question under discussion. Some conception will thus be obtained of what a lawsuit is which involves the reasonableness of rates, or the existence of an unjust discrimination, or a local rate as compared with a through rate. As the onus is upon the complainant, add to his difficulties the fact that his adversary has nearly all the evidence in his possession, locked up in books and in the memory and intelligence of experts who have made the subject their study. The expense involved, the uncertainty to be faced, and the difficulties to be overcome in an ordinary suit at law have made that remedy obsolete and useless.

All these considerations, fully corroborated as they are by the evidence submitted, have satisfied the committee that the common law wholly fails to afford an effective remedy against unreasonable or discriminating rates, and that, without additional legislation, the carrier is practically the sole and only judge of the rights of the producer and shipper in respect to transportation.

2. It is the duty of Congress to undertake the regulation of the business of transportation, because of admitted abuses in its management and of acknowledged discriminations between persons and places in its practical operation—evils which it is possible to reach and remedy only through the exercise of the powers granted by the Constitution to Congress, and against which the citizen is entitled to the protection and relief the national authority can alone afford.

Attention will be called hereafter to these causes of complaint; and it is perhaps only necessary to suggest here that the railroad argument against legislation on the ground that competition, the laws of trade, and an "enlightened self-interest" afford all needful protection and the most effective regulation, is predicated upon the conditions which prevail at the great commercial centers and in favored localities where competition is most active, and applies more particularly to the larger shippers, who are always able to take care of themselves and at such

points can usually depend for protection and fair treatment upon the eagerness of the corporations to capture all the business possible. But it should be the aim of the law to protect the weak, and it is at the great number of non-competitive interior points, scattered all over the land, at which even the protection elsewhere afforded by competitive influences is not found, and where the producer and shipper are most completely in the power of the railroads, that additional safeguards are most needed.

3. National legislation is necessary to remedy the evils complained of, because the operations of the transportation system are, for the most part, beyond the jurisdiction of the States, and, until Congress acts, not subject to any governmental control in the public interest.

The States have no power to regulate interstate commerce, and it appears from the evidence that even their control of their own domestic traffic is restricted and frequently made inoperative by reason of its intimate intermingling with interstate commerce and by the present freedom of the latter from any legislative restrictions. Some of the difficulties of effective State regulation in the absence of national legislation have been pointed out elsewhere in this report, and illustrations have been given of the greater volume and importance of interstate as compared with State traffic. National supervision would supplement, give direction to, and render effective State supervision, and is especially necessary as the only method of securing that uniformity of regulation and operation which the transportation system requires for its highest development.

The clearly-established fact that, by reason of the constitutional division of powers between the States and the General Government, the States have been able only to partially control the business of transportation within their own borders has been the principal inciting cause of the popular demand for national regulation, and is sufficient, in the judgment of the committee, to call for such action by Congress as will make effective the means of regulation found necessary and adopted by the States.

4. National legislation is also necessary, because the business of transportation is essentially of a nature which requires that uniform system and method of regulation which the national authority can alone prescribe.

The key-note to all the decisions of the United States Supreme Court concerning the power to regulate commerce is found in the declaration made in Cooley *v.* Board of Wardens, and frequently

referred to in other cases, that "whatever subjects of this power are in their nature national, or admit only of one uniform system or plan of regulation, may justly be said to be of such a nature as to require exclusive legislation by Congress;" and, as is said by the court in the late case of Gloucester Ferry Company *v.* Pennsylvania, "it needs no argument to show that the commerce with foreign nations and between the States, which consists in the transportation of persons and property between them, is a subject of national character, and requires uniformity of regulation. Congress alone, therefore, can deal with such transportation."

5. The failure of Congress to act is an excuse for the attempts made by the railroads to regulate the commerce of the country in their own way and in their own interests by whatever combinations and methods they are able to put into operation.

Through the absence of national legislation the railroads of the United States have been left to work out their own salvation. The practical results of their efforts have been by no means encouraging, as the present depressed condition of the railway interests bears witness, nor do they claim to have made any substantial progress during the past fifteen or twenty years. It is true that in this period the railroads have accomplished wonders in reducing the cost of transportation, in removing the limitations of distance from trade between remote localities, and in building up and widely extending the general commerce of the country. But, notwithstanding all these marvelous achievements, for which due credit should be given, the solid fact still claims consideration, that the inequalities and discriminations which characterize the operations of the system in its entirety are now as pronounced as in the earlier stages of its development.

In the recognized existence of these evils and in the failure of the national authority to offer any remedy, railroad managers have found their justification for seeking a remedy through methods which have not commended themselves to the public judgment and which have threatened even greater dangers to the body-politic. In the absence of national legislation, the railroads have naturally resorted to the only methods by which they could unaided secure any degree of stability and uniformity in their charges—consolidations and confederation. The final outcome of continued consolidation would be the creation of an organization more powerful than the Government itself and perhaps beyond its control. The same result might follow the successful develop-

ment of the policy of confederation or pooling, if unrestricted by Governmental supervision, and either would be inimical to the public interest. But while this would be the logical outcome of the existing tendency of railway organization and management, there are satisfactory reasons for believing that it will not be the actual result, and that this policy has substantially reached the limit to which it can be carried. In a sense it may be true that the railroad properties of the country are to-day largely within the control of a comparatively small circle, yet the colossal combinations which have been effected find other gigantic combinations equally as powerful successfully contending for the traffic of the territory they seek to control. The vast geographical extent of the country, its immense resources, the diverse interests of different sections, the abundance of capital, the commanding influence and the enterprise of the great commercial centers, the impossibility of controlling 35,000 miles of free water-routes—all these considerations lessen the dangers to be apprehended from future consolidations and combinations, and at the same time show how difficult it will be for the railroads to work out the problem alone and unaided.

Experience and investigation have up to this time failed to indicate how the inequalities and discriminations complained of, which have grown into and become a fundamental part of the system upon which the business of the entire country is conducted, are to be done away with without a serious disturbance of every individual and public business interest. To equalize through and local rates, and to give them that degree of uniformity and stability so greatly needed, must necessarily involve a complete readjustment and reconstruction of the commercial relations and business methods of the whole country. How this is to be accomplished is the secret which underlies the satisfactory solution of the railroad problem.

That a problem of such magnitude, importance, and intricacy can be summarily solved by any master-stroke of legislative wisdom is beyond the bounds of reasonable belief. That the railroads, unaided or unrestrained, can or will eventually work out its solution seems highly improbable, judging from past experience, and cannot reasonably be expected. That a satisfactory solution of the problem can ever be secured without the aid of wise legislation the committee does not believe.

THE CAUSES OF COMPLAINT AGAINST THE RAILROAD SYSTEM.

The complaints against the railroad system of the United States expressed to the committee are based upon the following charges:

1. That local rates are unreasonably high, compared with through rates.

2. That both local and through rates are unreasonably high at non-competing points, either from the absence of competition or in consequence of pooling agreements that restrict its operation.

3. That rates are established without apparent regard to the actual cost of the service performed, and are based largely on "what the traffic will bear."

4. That unjustifiable discriminations are constantly made between individuals in the rates charged for like service under similar circumstances.

5. That improper discriminations are constantly made between articles of freight and branches of business of a like character, and between different quantities of the same class of freight.

6. That unreasonable discriminations are made between localities similarly situated.

7. That the effect of the prevailing policy of railroad management is by an elaborate system of secret special rates, rebates, drawbacks, and concessions, to foster monopoly, to enrich favored shippers, and to prevent free competition in many lines of trade in which the item of transportation is an important factor.

8. That such favoritism and secrecy introduce an element of uncertainty into legitimate business that greatly retards the development of our industries and commerce.

9. That the secret cutting of rates and the sudden fluctuations that constantly take place are demoralizing to all business except that of a purely speculative character, and frequently occasion great injustice and heavy losses.

10. That, in the absence of national and uniform legislation, the railroads are able by various devices to avoid their responsibility as carriers, especially on shipments over more than one road, or from one State to another, and that shippers find great difficulty in recovering damages for the loss of property or for injury thereto.

11. That railroads refuse to be bound by their own contracts, and arbitrarily collect large sums in the shape of overcharges in addition to the rates agreed upon at the time of shipment.

12. That railroads often refuse to recognize or be responsible for the acts of dishonest agents acting under their authority.

13. That the common law fails to afford a remedy for such grievances, and that in cases of dispute the shipper is compelled to submit to the decision of the railroad manager or pool commissioner, or run the risk of incurring further losses by greater discriminations.

14. That the differences in the classifications in use in various parts of the country, and sometimes for shipments over the same roads in different directions, are a fruitful source of misunderstandings, and are often made a means of extortion.

15. That a privileged class is created by the granting of passes, and that the cost of the passenger service is largely increased by the extent of this abuse.

16. That the capitalization and bonded indebtedness of the roads largely exceed the actual cost of their construction or their present value, and that unreasonable rates are charged in the effort to pay dividends on watered stock and interest on bonds improperly issued.

17. That railroad corporations have improperly engaged in lines of business entirely distinct from that of transportation, and that undue advantages have been afforded to business enterprises in which railroad officials were interested.

18. That the management of railroad business is extravagant and wasteful, and that a needless tax is imposed upon the shipping and traveling public by the unnecessary expenditure of large sums in the maintenance of a costly force of agents engaged in a reckless strife for competitive business.

### THE ESSENCE OF THE COMPLAINTS

It will be observed that the most important, and in fact nearly all, of the foregoing complaints are based upon the practice of discrimination in one form or another. This is the principal cause of complaint against the management and operation of the transportation system of the United States, and gives rise to the question of greatest difficulty in the regulation of interstate commerce.

It is substantially agreed by all parties in interest that the great desideratum is to secure equality, so far as practicable, in the facilities for transportation afforded and the rates charged by the instrumentalities of commerce. The burden of complaint is against unfair differences in these particulars as between different places, persons, and commodities, and its essence is that these differences are unjust in comparison with the rates allowed or facilities afforded to other persons and places for a like service under similar circumstances.

The first question to be determined, apparently, is whether the inequalities complained of and admitted to exist are inevitable, or whether they are entirely the result of arbitrary and unnecessary discrimination on the part of the common carriers of the country; and the consideration of this question suggests an inquiry as to the proper basis upon which rates of transportation should be established.

# PLANS OF GOVERNMENT FOR MUNICIPALITIES

Within the last twenty years, the American people have given considerable thought and discussion to the problems of municipal government. Under conditions where the government of a city was a matter of partisan politics, good government was the exception. As a result the country has come to see that municipal government is a matter of business and should be conducted on sound business principles. To this end, many forms of city government have been devised and are being tried with varying degrees of success. Many states have dealt with this problem of statutory enactment, some favoring one plan and some another. The State of Ohio, for one, has recently enacted a law which permits the citizens of any municipality to decide for themselves which form of government they shall adopt, thus allowing them to try out and test the merits and demerits of the most important plans that have as yet been devised. This law provides for the adoption of what are known as the Commission form, the City Manager form, and the Federal plan of municipal government. The text of this law is as follows:

## ARTICLE I. ADOPTION OF PLAN

Section 1. Whenever electors of any municipality, equal in number to ten percentum of those who voted at the last regular municipal election, shall file a petition with the board of deputy state supervisors of elections or board of deputy state supervisors and inspectors of election, as the case may be, of the county in which such municipality is situated, asking that the question of organizing the municipality under any one of the plans of government provided in this act be submitted to the electors thereof, said board shall at once certify that fact to the council of the municipality and the council shall, within thirty days, provide for submitting such question at a special election to be held not less than sixty nor more than ninety days after the filing of such petition. Any such election shall be conducted in accordance with the

general election laws of the state except as otherwise provided in this act and the council of any municipality holding such an election shall appropriate whatever money may be necessary for the proper conduct thereof.

Sec. 2. The proposition to adopt a plan of government provided in this act shall not be submitted to the electors of any municipality less than ninety days before a regular municipal election. If in any municipality, a sufficient petition is filed, requiring that the question of choosing a commission to frame a charter be submitted to the electors thereof, the proposition to adopt a plan of government provided in this act shall not be submitted in that municipality as long as the question of choosing such commission or adopting a charter framed thereby is pending therein. In any municipality while the proposition of adopting any one of the three forms of government herein provided for is pending, then no other proposition herein provided for shall be submitted until said pending proposition is adopted or rejected.

Sec. 3. In submitting the question of organizing under any one of the plans of government provided in this act to the electors of any municipality the board of deputy state supervisors of elections or board of deputy state supervisors and inspectors of elections, as the case may be, shall cause to be printed on the ballots the following question, "Shall the (name the plan) plan of government, as provided in chapter ...... section ...... of the General Code of Ohio be adopted? Immediately following such question there shall be printed on the ballots the following propositions in the order here set forth:

"For the adoption of the (............) plan."

"Against the adoption of the (............) plan."

When the question is on the adoption of the federal plan of government there shall also be submitted the question "For councilmen-at-large," and "For councilmen-by-wards."

There shall also be printed on the ballots at any such election the following supplementary proposition.

"For the adoption of the recall."

"Against the adoption of the recall."

Immediately to the left of each of the propositions shall be placed a square in which the electors by making a cross (X) mark may vote for or against any such propositions.

At least thirty days prior to any such election the deputy state supervisors of elections or board of deputy state supervisors and inspectors of elections, as the case may be, of the county shall mail a copy of

the proposed plan of government and the supplementary propositions as specified in this act to each elector of the municipality whose name appears on the poll or registration books of the last regular general election, and each such copy shall contain on the front cover thereof a facsimile ballot and the date and hours of the election. Any elector may, at least forty days prior to such election file, with said board a written argument of not more than three hundred words for or against any proposed plan of government or for or against any other proposition submitted and, upon payment of the cost of printing, said board shall cause the same to be printed and a copy thereof mailed with the copy of the proposed plan to each elector or otherwise distributed to every voter as far as practicable.

Sec. 4. If, when submitted in any municipality the proposition of adopting a plan of government provided in this act is approved by a majority of those voting thereon, such plan, together with any of the supplementary propositions that may have been approved by a majority of the electors voting thereon, shall become the charter of such municipality. When so adopted, this act shall go into effect immediately, in so far as it applies to the nomination and election of officers provided for herein and in all other respects it shall go into effect upon the first day of January following the next regular municipal election. All officers of any plan of governments superseded by the adoption of any plan provided in this act, except members of the commission or council, shall continue in office and in the performance of their duties until the commission or council elected hereunder shall have provided by ordinances for the performance of the duties of such officers, whereupon the terms of all such officers shall expire and their offices be deemed abolished.

Sec. 5. In any municipality where a plan of government provided in this act has been adopted any of the supplementary propositions, not previously adopted, may be independently submitted to the electors at any municipal election in the manner provided for submitting the question of adopting such plan of government. If the proposition to adopt a plan of government provided in this act is rejected by the electors of a municipality, it shall not again be submitted in that municipality within one year thereafter.

Sec. 6. Immediately after an election upon the adoption of any plan of government or proposition provided herein the board of deputy state supervisors of elections or board of deputy state supervisors and inspectors of elections, as the case may be, of the county in which

such election is held shall file with the secretary of state a certificate of the results thereof.

## Article II. Election Provisions

Section 1. Applicable to each plan. The sections of this article shall apply to and be a part of each of the plans of government provided in this act.

Sec. 2. Nominations and elections. Regular municipal elections shall be held on the first Tuesday after the first Monday in November in the odd numbered years, and shall be conducted and the results canvassed and announced by the regular election authorities. Candidates to be voted for at the regular municipal elections shall be nominated as provided by law.

Sec. 3. Ballots. The ballots used in all elections provided for in this act shall be without party marks or designations. The names of candidates on such ballots shall be printed in rotation as follows: The ballots shall be printed in as many series as there are candidates for the office for which there is the greatest number of candidates. The whole number of ballots to be printed shall be divided by the number of series and the quotient so obtained shall be the number of ballots in each series. In printing the first series of ballots the names of candidates for each office shall be arranged in alphabetical order under the title thereof. After printing the first series the first name in each list of candidates for the various offices shall be placed last in such list and the next series printed, and the process shall be so repeated until each name in the largest list of candidates shall have been printed first an equal number of times. The ballots so printed shall then be combined in tablets, so as to have the fewest possible ballots having the same order of names printed thereon together in the same tablet. The ballots shall in all other respects conform as nearly as may be to the ballots prescribed by the general election laws of the state.

Sec. 4. Regular election. The candidates at the regular municipal election, equal in number to the places to be filled in each office, who received the highest number of votes, shall be declared elected. In case it cannot be determined which of two or more candidates shall be declared elected, by reason of the fact that they have received the same number of votes, the election authorities shall determine by lot which of said candidates shall be declared elected.

## Article III. Commission Plan

Section 1. Form of government. The form of municipal government provided for in this article shall be known as the commission plan. In municipalities organized hereunder the only elective officers shall be the members of the municipal commission provided for in this act. Three commissioners shall be chosen in municipalities having not more than 10,000 inhabitants according to the last preceding federal census and five commissioners in all other municipalities. All such commissioners shall be elected from the municipality at large.

Sec. 2. Election: term: vacancies. At the first election held after the adoption of the commission plan the entire number of commissioners shall be chosen. In municipalities having three commissioners the candidate having the highest number of votes at such first election shall hold office for four years and the remaining commissioners for two years. In municipalities choosing five commissioners the two candidates receiving the highest number of votes at such first election shall serve for four years and the remaining commissioners for two years. At all subsequent elections except where a commissioner is chosen to fill out an unexpired term, commissioners shall be chosen for a term of four years. Vacancies in the commission shall be filled by the commission for the remainder of the unexpired term. If the term of a commissioner whose place becomes vacant does not expire on the first day of January following the next regular municipal election, then such person chosen by the commissioners shall serve only until such regular election, at which time a commissioner shall be elected to fill the remainder of the unexpired term. When a vacancy occurs as the result of a recall election such vacancy shall be filled in the manner provided for such cases.

Sec. 3. Meetings of commission. At ten o'clock a. m. on the first day of January following a regular municipal election the commission shall meet at the regular place for holding such meetings, at which time the newly elected commissioners shall assume the duties of their office. Thereafter the commission shall meet in legislative session at least twice each month and in administrative session at least once each week, at such times as may be prescribed by ordinance or resolution, but no legislative business shall be considered or acted upon at administrative sessions. Upon written request of the chairman or any two members special legislative sessions of the commission shall be called by the clerk. Any such request shall state the subjects to be

considered at such special meeting and no other subject shall be there considered.

Sec. 4. Signing of ordinances. Every ordinance or resolution passed by the commission shall be signed by the chairman or two members, filed with the clerk within two days and by him recorded.

Sec. 5. Powers of the commission. The powers conferred upon municipalities by the constitution of Ohio, and any additional powers which have been or may be conferred upon municipalities by the general assembly, shall be exercised by the commission or under its direction, unless the exercise of such powers shall have been expressly conferred upon some other authority of the municipality or reserved to the people thereof.

Sec. 6. Administrative officers. The commission shall appoint a clerk, treasurer, auditor and solicitor; but provision may be made by ordinance for the performance of the duties of clerk and treasurer by the same person.

Sec. 7. Creation and discontinuance of offices. Subject to the provisions of this act the commission shall have authority to create and discontinue departments, offices, and employments; to appoint or provide for the appointment of all officers and employees of the municipality; to remove any such officers or employee by a majority vote of all members and by ordinance or resolution to prescribe, limit or change the compensation of such officers and employees.

Sec. 8. Supervision by commissioners. The commission may, at its discretion, assign the direction or supervision of particular departments or branches of the government to individual commissioners; but such action shall in no manner release the commission as a whole from responsibility or the condition of any department or branch of government so assigned.

## Article IV. City Manager Plan

Section 1. General description. The form of government provided in this article, to be known as the "City Manager Plan," shall consist of a council of five or more citizens, according to the population of the municipality as determined by the last preceding census, who shall be elected at large. The council shall constitute the governing body of such city with power to pass ordinances, adopt regulations, appoint a chief administrative officer, to be known as the city manager, approve all appointments made by the city manager, except as other-

wise provided in this act, fix all salaries, appoint a civil service commission and all boards or commissioners created by ordinance.

Sec. 2. Size and term of council-vacancies. The number of councilmen shall be in proportion to the population of the municipality, as determined by the last preceding federal census, as follows: A municipality having not more than ten thousand inhabitants, five; more than ten thousand and not more than twenty-five thousand inhabitants, seven; more than twenty-five thousand inhabitants, nine. All councilmen shall serve for a term of four years and until their successors are elected and have qualified. Except that at the first election in municipalities having five councilmen, the candidates having the three highest number of votes shall serve for four years, the other two councilmen shall serve for two years, and in muncipalities having more than five councilmen the majority of councilmen having the highest number of votes shall serve for a period of four years and the others for a period of two years. Vacancies in the council shall be filled by the council for the remainder of the unexpired term, but any vacancy resulting from a recall election shall be filled in the manner provided for in such cases.

Sec. 3. Meetings of council. The council shall meet at the usual place for holding such meetings, at ten o'clock a. m. on the first day of January after its election, at which time the newly elected councilmen shall assume the duties of their office. Thereafter the council shall meet in regular session at least twice each month at such times and places as shall be fixed by ordinance. The clerk shall call special sessions of the council upon written request of the chairman or of any two members. Any such requests shall state the subjects to be considered at such special meeting and no other subject shall be there considered.

Sec. 4. Signing of ordinance. Every ordinance or resolution passed by the council shall be signed by the chairman or two members, filed with the clerk within two days and by him recorded.

Sec. 5. Powers of the council. The powers conferred upon municipalities by the constitution of Ohio, and any additional powers which have been or may be conferred upon municipalities by the General Assembly, shall be exercised by the council unless the exercise of such powers shall have been expressly conferred upon some other authority of the municipality or reserved to the people thereof.

Sec. 6. Administrative officers. The council shall appoint a clerk, treasurer, auditor and solicitor; but provision may be made by

ordinance for the performance of the duties of clerk and treasurer by the same person.

Sec. 7. Creation and discontinuance of offices. Subject to the provisions of this act, the council shall have authority to create and discontinue departments, offices and employments; to appoint or provide for the appointment of all officers and employees of the municipality; to remove any such officer or employee by a majority vote of all members and by ordinance or resolution to prescribe, limit or change the compensation of such officers and employees.

Sec. 8. City manager. The council shall appoint a city manager who shall be the administrative head of the municipal government under the direction and supervision of the council and who shall hold office at the pleasure of the council.

Sec. 9. Duties city manager. The duties of the city manager shall be: (a) to see that the laws and ordinances are faithfully executed; (b) to attend all meetings of the council at which his attendance may be required by that body; (c) to recommend for adoption to the council such measures as he may deem necessary or expedient; (d) to appoint all officers and employees in the classified service of the municipality, subject to the provisions of this act and the civil service law; (e) to prepare and submit to the council such reports as may be required by that body, or as he may deem advisable to submit; (f) to keep the council fully advised of the financial condition of the municipality and its future needs; (g) to prepare and submit to the council a tentative budget for the next fiscal year; (h) and to perform such other duties as the council may determine by ordinance or resolution.

Sec. 10. Salary of city manager. The city manager shall receive such salary as may be fixed by the council; and before entering upon the duties of this office he shall take the official oath required by this act and shall execute a bond in favor of the municipality for the faithful performance of his duties in such sum as may be fixed by the council.

### Article V. Federal Plan

Section 1. Form of government. The form of government provided for in this article shall be known as the federal plan. In municipalities adopting this plan the only elective officers shall be mayor and members of council as provided for in this act. The mayor, the auditor, and heads of departments appointed by the mayor, shall constitute a board of control as hereinafter provided.

Sec. 2. Council. Term and number of members. All legislative power of the municipality shall be vested in a council consisting of not less than five (5) nor more than fifteen (15) members. In municipalities of less than ten thousand population members of the council shall be elected at large; in all others they shall be elected from wards or at large, as determined by the vote provided for in article 1, section 3, hereof. The term of office shall be two years when the council is elected by wards and four years when the council is elected at large. Except that at the first election in municipalities where the council is elected at large, and having three councilmen, the candidates having the two highest number of votes shall serve for four years, the other councilman shall serve for two years, and in such municipalities having more than three councilmen the majority of councilmen having the highest number of votes shall serve for a period of four years and the others for a period of two years. When the council is elected by wards the number of councilmen shall be in proportion to the population of the municipality, as determined by the last preceding federal census, as follows: A municipality having not more than ten thousand inhabitants, five councilmen; more than ten thousand and not more than twenty-five thousand, seven councilmen; more than twenty-five thousand and not more than fifty thousand, nine councilmen; and for each twenty-five thousand inhabitants in excess of fifty thousand, the number shall be increased by one; but the total number of councilmen shall not exceed fifteen. When the council is elected at large the number of councilmen shall be in proportion to the population of the municipality as determined by the last preceding federal census, as follows: A municipality not having more than ten thousand inhabitants, three councilmen; more than ten thousand and not more than twenty-five thousand, five councilmen; more than twenty-five thousand and not more than fifty thousand, seven councilmen, and for each twenty-five thousand inhabitants in excess of fifty thousand the number shall be increased by one, but the total number of councilmen shall not exceed nine.

Sec. 3. Wards. When cities have a council elected by wards. For the first election of members of the council after the adoption of the federal plan, in any municipality having ten thousand inhabitants or more, the municipality shall be divided into wards by the legislative authority existing under the plan of government to be superseded. Immediately after the proclamation by the secretary of state as to the population of the municipalities of Ohio, as determined by the federal

census decennially taken, the council shall have power to re-divide the municipality into wards upon the basis of its population; the object and purpose being that the wards of any municipality as fixed hereunder shall be as nearly equal in population as may be and composed of contiguous and compact territory, bounded by natural boundaries or street lines. Any member of the council elected from wards, who, at any time for his election was a resident of the ward which he represents shall forfeit his office if he removes from such ward, and the council shall fill the vacancy for the unexpired term.

Sec. 4. Meeting of council. At ten o'clock a. m. on the first day of January following a regular municipal election the council shall meet at the usual place for holding such meetings, at which time the newly elected councilmen shall assume the duties of their office. Thereafter the council shall meet at such times as may be prescribed by ordinance or resolution; but it shall meet at least twice each month. Special sessions of the council shall be called by the clerk upon written request of the mayor, the chairman, or any two members. Any such report shall state the subjects to be considered at the meeting and no other subjects shall be there considered.

Sec. 5. Mayor's veto. Any ordinance or resolution passed by the council shall be signed by the chairman or two members and presented to the mayor. If the mayor approves such ordinance or resolution he shall sign it, but if he does not approve it, he shall return the same to the council with his objections within ten days thereafter or if the council be not then in session at the next regular meeting thereof, which objections the council shall cause to be entered in full on its journal. If the mayor does not return an ordinance or resolution within the time specified it shall take effect in the same manner as if he had signed it. The mayor may approve or disapprove the whole or any item or part of any ordinance or resolution appropriating money. When the mayor refuses to sign any ordinance or resolution or part thereof and returns it to the council with his objections, the council shall, after the expiration of not less than one week, proceed to reconsider it, and if upon reconsideration the resolution or ordinance or part; or item thereof disapproved by the mayor is approved by the vote of two-thirds of all the members elected to the council, it shall then take effect as if it had received the signature of the mayor. In all such cases the votes shall be taken by "yeas" and "nays" and entered on the journal.

Sec. 6. Creation and discontinuance of offices. The council

shall have authority to create and discontinue departments and offices other than those provided for in this act, and to provide for the appointment of all such officers, but the functions and number of sub-departments, and the number and salaries of subordinates and employees shall be fixed by the executive heads of the various departments, all of which provisions, however, shall be subject to the rules and regulations of the civil service commission as authorized by law.

Sec. 7. The executive power. The executive power of the municipality shall be vested in the mayor, the heads of the departments hereinafter named, and such other executive officers as are provided for herein or as shall be provided for by ordinance.

Sec. 8. The mayor. The mayor shall be elected at the regular municipal election for a term of four years and shall assume office on the first day of January next following his election. He shall appoint a director of public service, a director of public safety, a solicitor, and a treasurer. The council may provide by ordinances for combining the offices and duties of the directors of public service and public safety. The mayor and heads of departments shall not hold any other federal, state, county or municipal office, except that of notary public or member of the state militia, nor be an employee in any such office.

Sec. 9. Powers and duties of mayor. The duties of the mayor shall be (a) to see that the laws and ordinances are enforced; (b) to recommend to the council for adoption such measure as he may deem necessary or expedient; (c) to keep the council fully advised of the financial condition and future needs of the municipality; (d) to prepare and submit to the council such reports as may be required by that body; (e) to appoint, whenever he deems it necessary, competent, disinterested persons not exceeding three in number, to examine without notice the affairs of any department, officer, or employee, and the result of such examination shall be reported to his office, and also transmitted to him by the council without delay; (f) to perform such other duties as the council may determine by ordinance or resolution, not in conflict with the provisions of this article. Any person or persons appointed by the mayor to examine the affairs of any department, officer, or employee, shall have the same power to compel the attendance of witnesses and to compel the production of books, papers and other evidence and to punish for contempt, as is conferred upon the council or committee thereof, by this act.

Sec. 10. Appointment and removal of officers. Subject to the provisions of this act, all officers, clerks and employees of the several

departments and sub-divisions thereof, shall be appointed, employed, suspended or removed by the head of the department. The mayor may, without assignment of reason, remove any department head appointed by him.

Sec. 11. Acting mayor. If the mayor be temporarily absent from the municipality, or become temporarily disabled by sickness, accident, or for any other cause, the heads of the departments named in this act shall during such absence or disability perform the duties of the mayor under the designation of the acting mayor in the following order: solicitor, director of public service, director of public safety, auditor, treasurer. If the mayor should die or remove his residence from the municipality during the term of his office, the succession to the office of mayor shall be from the heads of the departments in the same order as aforesaid, and such successor shall become the mayor of the municipality for the unexpired term. In the event of any temporary disability or absence on the part of any director or head of department hereinbefore provided for, the mayor may in writing designate some suitable person to perform his duties until he resumes office.

Sec. 12. Director of public service. The department of public service shall be under the charge of a director to be appointed by the mayor as hereinbefore provided. He shall have the care, management, construction and improvement of all utilities owned or operated by the municipality; of all public ways, grounds, cemeteries, buildings, sewers and structures of every kind, except buildings and structures used in connection with the work to be performed under the direction of the director of public safety as hereinafter provided; of the making and preserving of survey maps, plans, drawings and estimates relating to the public work under the charge of the department; and of all matters and things in any way relative to or affecting the highways, footways, water ways, harbors, wharves and docks, within the municipality, and he shall exercise the powers heretofore vested in the trustee of waterworks, park commissions, platting commissions, street commissions, city engineers, or other board of officers relating to the work herein committed to the care and management of the director of public service.

Sec. 13. Director of public safety. The department of public safety shall be under the charge of a director to be appointed by the mayor as hereinbefore provided. The director of public safety shall have charge of the police, fire, health, charities and corrections, and building inspection of the municipality, and all powers and authority by any general law heretofore vested in boards or offices having author-

ity over police, fire, health, charity and corrections, and building inspection shall be, and are hereby vested in the director of public safety. He shall have charge of the administration of all infirmaries, charitable, correction and penal institutions. He shall make such rules and regulations as are necessary and proper for the employment, discipline, instruction, education, reformation, and the conditional release and return of all prisoners confined in any penal institution under his control.

Sec. 14. Board of control. There shall be a board of control composed of the mayor, who shall be the president thereof, the auditor, and the heads of the departments appointed by the mayor. The board of control shall have stated meetings at least twice a week; shall keep a record of its proceedings; shall cause its votes to be taken by yeas and nays, and entered on the record, and a majority of all the members of the board shall be necessary to adopt any motion or order. No ordinance or resolution involving any expenditure of money for public improvements shall be passed until the same shall have been approved by the board of control, except upon a two-thirds vote of the council.

Sec. 15. Seats in council. The mayor and the heads of the several departments shall have seats in the council. The mayor shall be entitled to introduce ordinances and take part in its proceedings and deliberations on all questions, and the heads of departments shall be entitled to take part in its proceedings and deliberations on all questions relating to their respective departments, subject to such rules as the council shall from time to time prescribe, but without the right to vote.

Sec. 16. Powers of municipality. In municipalities adopting the federal plan, the powers conferred upon municipalities by the constitution of Ohio, and any additional powers which have been or may be conferred upon municipalities by the General Assembly shall be exercised by the officers and authorities provided for in this article, unless the exercise of such powers shall have been expressly conferred upon some other authority of the municipality or reserved to the people thereof.

## Article VI. General Provisions—Applicable to Each Plan

Section 1. Applicable to each plan. The sections of this article shall apply to and be a part of each plan of government provided in this act. The powers conferred upon municipalities by the municipal Code so far as applicable shall govern unless otherwise provided by

law. Such provisions may be proposed by the legislative authority of any municipality, or by the electors of such municipality by petition in the manner prescribed by law for the submission of initiative petitions. Such provisions shall take effect and be in force when approved by the majority of the electors voting thereon. In municipalities adopting the commission plan of government provided in this act, the term "council," as used in this article and in article VII, shall be held to refer to the commission.

Sec. 2. Treasurer. The treasurer shall be the custodian of all moneys of the municipality, and shall keep and preserve the same in such manner and in such place or places as shall be determined by the council. He shall pay out money only on warrants issued by the auditor.

Sec. 3. The auditor. The council shall choose an auditor whose duty it shall be to keep an accurate account of all taxes and assessments, of all money due to and all receipts and disbursements by the municipality, of all assets and liabilities of the municipality, and of all appropriations made by the council. He shall at the end of each fiscal year, and oftener if required by the council, audit the accounts of the several departments and officers, and shall audit all other accounts in which the municipality is interested. He may prescribe the form of reports to be rendered to his department, and the method of keeping accounts by all other departments, and he shall require daily reports to be made to him by each department showing the receipt of all moneys by such department and the disposition thereof. The auditor shall, upon the death, resignation, removal, or expiration of the term of any officer, audit the accounts of such officer, and if such officer shall be found indebted to the municipality he shall immediately give notice thereof to the council and the solicitor, and the latter shall forthwith proceed to collect the same.

Sec. 4. Payment of claims. No warrant for the payment of any claim shall be issued by the auditor until such claim shall have been approved by the head of the department for which the indebtedness was incurred, and each head of department and his surety shall be liable to the municipality for all loss or damage sustained by the municipality by reason of the negligence or corrupt approval of any claim against the municipality in his department. Whenever any claim shall be presented to the auditor he shall have power to require evidence that the amount claimed is justly due and is in conformity to law and ordinance, and for that purpose he may summon before him any officer,

agent, or employee, or any department of the municipality, or any other person, and examine him upon oath or affirmation relative thereto, which oath or affirmation he may administer.

Sec. 5. Clerk. The council shall choose a clerk and such other officers and employees of its own body as may be deemed necessary. The clerk shall keep the records of the council and perform such other duties as may be required by ordinance or resolution. All officers and employees chosen by the council shall serve during the pleasure thereof.

Sec. 6. Solicitor. The solicitor shall act as the legal adviser to and attorney and counsel for the municipality, and for all officers in matters relating to their official duties. He shall prepare all contracts, bonds, and other instruments in writing in which the municipality is concerned, and shall indorse on each his approval of the form and correctness thereof, and no contract with such municipality shall take effect until the approval of the solicitor is indorsed thereon. He or his assistants shall be the prosecutor or prosecutors in any police or municipal court, and shall perform such other duties and have such assistants and clerks as may be required or provided.

Sec. 7. Qualifications of councilmen. Members of the council shall be electors of the municipality. They shall not hold any other public office or employment except that of notary public or member of the state militia, and shall not be interested in the profits or emoluments of any contract, job, work or service for the municipality. Any members who shall cease to possess any of the qualifications herein required shall forthwith forfeit his office and any such contract in which any member is or may become interested may be declared void by the council.

Sec. 8. Salaries and attendance of councilmen. The council shall by ordinance fix the salary of its members, which shall be paid in equal monthly installments. For each absence from regular meetings of the council, unless authorized by a two-thirds vote of all members thereof, there shall be deducted a sum equal to two per cent of such annual salary. Absence for ten successive regular meetings shall operate to vacate the seat of a member unless such absence is authorized by council.

Sec. 9. Chairman of council. At the first meeting following each regular municipal election, the council shall elect one of its members chairman, who shall preside at meetings of the council and perform such duties as may be imposed upon him as presiding officer, by the council.

Sec. 10. Legislative procedure. A majority of all members of

the council shall constitute a quorum to do business, but a smaller number may adjourn from day to day and compel the attendance of absent members. The affirmative vote of a majority of the members of the council shall be necessary to adopt any motion, ordinance or resolution, and on the passage of every ordinance or resolution the vote shall be taken by "yeas" and "nays" and entered upon the journal. Each proposed ordinance or resolution shall be in written or printed form, and shall not contain more than one subject, which shall be clearly stated in the title; provided, however, that general appropriation ordinances may contain the various subjects and accounts for which money are appropriated. No ordinance, unless it be declared an emergency measure, shall be passed until it has been read on three separate days, the first and second reading of which may be by title only, and in case said measure shall be printed and a copy thereof placed on the desk of each member, then said third reading may be by title only.

Sec. 11. Publication of ordinances. All ordinances or resolutions shall be in effect from and after thirty days from the date of their passage, except as otherwise provided in this act. Ordinances of a general nature, or providing for public improvements, or assessing property, shall, upon passage, be promptly published one time in not more than two newspapers of general circulation in the municipality. Such ordinances shall be printed in the body type of the paper under head lines in eighteen point type, which shall specify the nature of such legislation. For the publication of ordinances no newspaper shall be paid any higher price than its maximum bona fide commercial rate.

Sec. 12. Annual tax ordinances. An annual tax ordinance to determine the amount of the tax levy shall be prepared by the mayor, the chairman of the commission, or the city manager, as the case may be, under the direction of the council. For the purpose of preparing such ordinances the mayor, the chairman of the commission, or the city manager, as the case may be, shall require from the head of each office or department for which appropriations are made, a detailed statement, upon uniform blanks furnished by the mayor, the chairman of the commission, or the city manager, as the case may be, of the expenses of such office or department for the previous year or years and the estimated expense for the next year. The tax ordinance prepared by the mayor, the chairman of the commission, or the city manager, as the case may be, shall set forth in detail the probable revenues of the municipality from every source, in such form as to indicate the means by which it is proposed to provide for the estimated expenditures

set forth in such ordinance, and shall also include detailed statements of the contemplated expenditures of the municipality and of each office, department and functional division thereof. After the tax ordinance is prepared by the mayor, the chairman of the commission, or the city manager, as the case may be, opportunity shall be given, after at least one week's notice, for public hearings thereon. The ordinance shall then be submitted to the council and by them to the county budget commission, which shall fix the total maximum tax levy permitted to the municipality for the ensuing year. The council shall then fix the actual tax levy for the ensuing year, but such levy shall not be higher than the estimate submitted by the mayor, the chairman of the commission, or the city manager, as the case may be, or exceed the limit fixed by the county budget commission. Such levy shall not be higher than the maximum now provided for by law.

Sec. 13. Annual appropriation ordinance. An annual appropriation ordinance shall be prepared by the council from estimates submitted by the mayor, the chairman of the commission, or the city manager, as the case may be, in the manner as herein provided for the annual tax ordinance. The annual appropriation ordinance shall be submitted to the council at its first meeting in January and the total of any appropriation ordinance passed by the council shall not exceed the total balances carried over from the previous year, plus the estimated revenue of the current year. Supplemental appropriations shall not be made during the current year except from a contingent fund regularly set aside by the council in the annual appropriation ordinance or unless by an ordinance passed as an emergency measure.

Sec. 14. Limitation on appropriations. No money shall be drawn from the treasury of the municipality except in pursuance of appropriations made by the council, and whenever an appropriation is so made the clerk shall forthwith give notice to the auditor and treasurer. Appropriations may be made in furtherance of improvements or other objects or work of the municipality which will not be completed within the current year. At the end of each year all unexpended balances of appropriations shall revert to the respective funds from which the same were appropriated, and shall then be subject to future appropriations.

Sec. 15. Investigations by council. The council or any commission thereof authorized by it so to do shall have power to compel the attendance of witnesses and the production of books, papers and other evidence, at any meeting of the council, or any committee thereof, and for that purpose may issue subpoenas or attachments in any case of

injury or investigation, to be signed by the presiding officer of the council, or chairman of such committee, as the case may be, which shall be served and executed by any officer authorized by law to serve subpoenas and other processes, and if any witness shall refuse to testify to any acts within his knowledge, or to produce any papers or books in his possession, or under his control, relating to the matter under inquiry, before the council or any such committee, the council shall have power to commit the witness to prison for contempt. No witness shall be excused from testifying touching his knowledge or the matter under investigation in any such inquiry, but such testimony shall not be used against him in any criminal prosecution except for perjury.

Sec. 16. Reports of council—publicity. At the end of each year the council shall have printed an annual report, in pamphlet form, giving the classified statement of all receipts, expenditures, assets and liabilities of the municipality; a detailed comparison of such receipts and expenditures with those of year preceding; a summary of the council proceedings and a summary of the operations of the administrative departments for the previous twelve months. A copy of this report shall be furnished to the state bureau of accounting, the municipal library, and to any citizen of the municipality who shall apply therefore at the office of the clerk. Similar reports may be printed quarterly at the discretion of the council. All meetings of the council or committees thereof shall be public and any citizen of the municipality shall have access to the minutes and records thereof at all reasonable times.

Sec. 17. Civil service commission. Within ten days after the first officers assume their duties, in any city adopting a plan of government provided in this act, the commission in cities adopting the commission plan, the council in cities adopting the city manager plan and the mayor in cities adopting the federal plan, shall appoint three persons who shall constitute the municipal civil service commission. Not more than two of such persons shall be of the same political party and they shall serve, one for two years, one for four years and one for six years, and until their successors are appointed and have qualified. Upon the expiration of their respective terms of office, the appointing authority shall appoint their successors to hold office for a term of six years and until their successors are appointed and have qualified. Any vacancy in the civil service commission shall be filled by the appointing authority for the unexpired term. The appointing authority may at any time remove any of said civil service commissioners for misconduct, neglect

of duty or malfeasance in office, first having given such commissioner an opportunity of being publicly heard in person or by counsel in his own defense. The commission or council shall provide suitable rooms and all necessary supplies and equipment for the proper conduct of the duties of the civil service commission.

Sec. 18. Salaries and duties. The salaries of the civil service commissioners and of their assistants shall be determined by ordinance. The duties of the civil service commission shall be to enforce the provisions of the civil service law with respect to all offices and place of employment in such city. The civil service commission shall make such rules for the proper performance of its duties as it shall find necessary and expedient, and as are not inconsistent with the civil service law.

Sec. 19. Compensation. The salary of an elective officer shall not be changed during the term for which such officer was elected. All fees and perquisites authorized by law or ordinance appertaining to any office or officer in the municipal government shall be paid into the treasury, and unless otherwise provided shall be credited to the general fund, and no officer or employee of the municipality shall receive otherwise than as the representative of the municipality and for the purpose of paying same into the treasury any fee, present, gift, or emolument, or share therein, for official services, other than his regular salary or compensation, and any officer violating this prohibition shall thereby forfeit his office. No member of the council or other officer or employee thereof shall receive compensation for services rendered in any other department of the city government, nor shall they, nor any other officer, clerk, or employee of the municipality, act as agent or attorney for any person, company, or corporation, in relation to any matter to be affected by action of the legislative or any other department of the municipality, or by the action of any officer of the municipality. The violation of this prohibition shall be cause for removal.

Sec. 20. Duties of officers. The duties of all officers and employees shall be those prescribed by this act or by ordinance or resolution of the council.

Sec. 21. Bonds. The treasurer, auditor and such other officers or employees of the municipality as the council may direct, shall give a bond to the municipality for the faithful performance of their duties in the sum as the council may fix by ordinance or resolution. Premiums on official bonds may be paid by the municipality.

Sec. 22. Oath of office. Every officer of the municipality and every employee holding a position upon annual salary before entering

upon the duties of his office shall take and subscribe to an oath or affirmation, to be filed and kept in the office of the clerk, that he will support the constitution of the United States and the state of Ohio, and the charter and ordinances of the municipality; that he will not be influenced by any consideration except that of merit and fitness in the appointment or discharge of employees; that he will not make or authorize the expenditure of public money otherwise than for adequate consideration and efficient service to the municipality; that he will in all other respects faithfully discharge the duties of his position or office.

Sec. 23. Existing offices abolished. All offices, boards or commissions, except boards in charge of educational institutions, sinking fund and depository commissions, are hereby abolished; the title to any property controlled by such officers, boards or commissions is vested in the municipality; and their powers and duties shall be exercised and performed as provided in this act.

Sec. 24. Schedule. The powers which are conferred and the duties which are imposed upon any office or department of the municipality under the laws of the state, or any ordinance which is in force at the time of the taking effect of this act, shall, if such office or department is abolished in pursuance of the provisions of this act, be thereafter exercised and discharged by the officer, board or department upon whom is imposed corresponding functions, powers and duties under the provisions of this act. Nothing herein contained shall impair or effect the validity of any contract or bond executed or authorized prior to the adoption by any municipality of one of the plans provided for in this act. When any such contract or bond contains provisions that the same be enforced by some officer, board or department therein named and where by the adoption of any plan provided for in this act such office, board or department is abolished, the powers conferred and the duties imposed with reference to the same upon the officer, board or department which has been abolished shall thereafter be exercised and discharged by the officer, board or department upon whom is conferred or imposed like powers, functions or duties under the provisions of this act.

Sec. 29. Abandonment of plan. Any municipality which shall have operated for five years under any plan provided in this act may abandon such organization, and may adopt any organization or form of government provided by this act and designated in the petition by proceeding as follows: Upon the filing of a petition with the board of deputy state supervisors of elections or board of deputy state super-

visors and inspectors of elections, as the case may be, containing the names of not less than ten per cent of the electors of such municipality, a special election shall be called by the council at which the following proposition shall be submitted: "Shall the municipality of (.........) abandon the (.........) plan and adopt the (name) plan as provided in article (......) chapter (......) of the General Code?" If a majority of the votes cast at such special election be in favor of such proposition, the officers elected at the next succeeding regular municipal election shall be those prescribed by the statutes designated in the petition, and upon the qualification of such officers such municipality shall be and become organized under the statutes designated; but such change shall not affect the property, right or ability of any nature of such municipality, but shall extend merely to such change in its form of government. The election for such change shall be ordered and conducted, and the results declared as provided in section 2 of article I of this act, and in the general election laws of the state.

### Article VII. Initiative, Referendum and Recall

Section 1. Adoption. All laws pertaining to the Initiative and Referendum in municipalities shall apply to and become a part of each plan of government provided for in this act. The provisions of section 2 of this article shall be submitted to the electors of the municipality as prescribed in article I, section 3, hereof, with each and every plan of government, provided herein. Section 2 of this article shall form a part of any such plan of government and go into effect in such municipality only to the extent to which the provisions shall have been adopted as provided in article I, second 3, hereof.

Sec. 2. The recall. Any elective officer of any municipality may be removed from office by the qualified voters of such municipality. The procedure to effect such removal shall be as follows:

(1). A petition signed by qualified electors equal in number to at least fifteen per cent of the total votes cast at the last preceding general municipal election, and demanding the election of a successor to the person sought to be removed, shall be filed with the deputy state supervisors of elections or board of deputy state supervisors and inspectors of elections, as the case may be, which petition shall contain a general statement in not more than two hundred words of the grounds upon which the removal is sought. The form, sufficiency and regularity of any such petition shall be determined as provided in the general election laws.

(2). If the petition shall be sufficient, and if the person or persons whose removal is sought shall not resign within five days after the sufficiency of the petition has been determined, the council shall thereupon order and fix a day for holding an election to determine the question of his removal, and for the selection of a successor to each officer named in said petition, which election shall be held not less than thirty nor more than forty days from the finding of the sufficiency of the petition. The election authorities shall cause publication of notice and all arrangements to be made for holding such election, and the same shall be conducted and the result thereof returned and declared in all respects as are the results of general municipal elections.

(3). The nomination of candidates to succeed each officer sought to be removed shall be made without the intervention of a primary election by filing with the election authorities at least twenty days prior to such special election, a petition proposing a person for each such office, signed by electors equal in number to ten per cent of the total votes cast at the last preceding general municipal election for the head of the ticket.

(4). The ballots at such recall election shall conform to the following requirements; with respect to each person whose removal is sought, the question shall be submitted: "Shall (name of person) be removed from the office of (name of office) by recall?" Immediately following each such question there shall be printed on the ballots the two propositions in the order set forth:

"For the recall of (name of person)."

"Against the recall of (name of person)."

Immediately to the left of the proposition shall be placed a square in which the electors, by making a cross (X) mark, may vote for either of such propositions. Under each of said questions shall be placed the names of candidates to fill the vacancy. The name of the officer whose removal is sought shall not appear on the ballot as a candidate to succeed himself.

(5). In any such election, if a majority of the votes cast on the question of removal are affirmative, the person whose removal is sought shall thereupon be deemed removed from office upon the announcement of the official canvass of that election, and the candidate receiving the plurality of the votes cast for candidates for that office shall be declared elected. The successor of any person so removed shall hold office during the unexpired term of his predecessor. The question of the removal of any officer shall not be submitted to the electors until he

shall have served for at least one year of the term during which he is sought to be recalled. The method of removal herein provided is in addition to such other methods as may be provided by law. If, at any such recall election, the incumbent whose removal is sought is not recalled, he shall be repaid from the city treasury his actual and legitimate expenses for such election, but such sum shall not exceed fifty per cent of the sum which he is by law permitted to expend as a candidate at any regular municipal election.

# THE SINGLE TAX

By Henry George

In conceiving the theory of single tax, or a tax on land values only, Henry George presented the world with a new theory in political economy. He believed that his theory was, and offered it as a remedy for all the inequalities, injustices, and ills which have sprung from the present system of raising revenue and of the distribution of wealth. It promises not only political justice and equality, but also undertakes to solve the problems between capital and labor, the questions of wage, interest, profit, and the moral welfare of the people. In his masterful treatise, George first sets forth and discusses the evils resulting from the present system and then presents the single tax as his remedy. The following is his own presentation of his remedy, the Single Tax.

## THE TRUE REMEDY

We have traced the unequal distribution of wealth which is the curse and menace of modern civilization to the institution of private property in land. We have seen that as long as this institution exists no increase in productive power can permanently benefit the masses; but, on the contrary, must tend to still further depress their condition. We have examined all the remedies, short of the abolition of private property in land, which are currently relied on or proposed for the relief of poverty and the better distribution of wealth, and have found them all inefficacious or impracticable.

There is but one way to remove an evil—and that is, to remove its cause. Poverty deepens as wealth increases, and wages are forced down while productive power grows, because land, which is the source of all wealth and the field of all labor, is monopolized. To extirpate poverty, to make wages what justice commands they should be, the full earnings of the laborer, we must therefore substitute for the individual ownership of land a common ownership. Nothing else will go to the cause of the evil—in nothing else is there the slightest hope.

This, then, is the remedy for the unjust and unequal distribution of wealth apparent in modern civilization, and for all the evils which flow from it:

*We must make land common property.*

We have reached this conclusion by an examination in which every step has been proved and secured. In the chain of reasoning no link is wanting and no link is weak. Deduction and induction have brought us to the same truth—that the unequal ownership of land necessitates the unequal distribution of wealth. And as in the nature of things unequal ownership of land is inseparable from the recognition of individual property in land, it necessarily follows that the only remedy for the unjust distribution of wealth is in making land common property.

But this is a truth which, in the present state of society, will arouse the most bitter antagonism, and must fight its way, inch by inch. It will be necessary, therefore, to meet the objections of those who, even when driven to admit this truth, will declare that it cannot be practically applied.

In doing this we shall bring our previous reasoning to a new and crucial test. Just as we try addition by subtraction and multiplication

by division, so may we, by testing the sufficiency of the remedy, prove the correctness of our conclusions as to the cause of the evil.

The laws of the universe are harmonious. And if the remedy to which we have been led is the true one, it must be consistent with justice; it must be practicable of application; it must accord with the tendencies of social development, and must harmonize with other reforms.

All this I propose to show. I propose to meet all practical objections which can be raised, and to show that this simple measure is not only easy of application; but that it is a sufficient remedy for all the evils which, as modern progress goes on, arise from the greater and greater inequality in the distribution of wealth—that it will substitute equality for inequality, plenty for want, justice for injustice, social strength for social weakness, and will open the way to grander and nobler advances of civilization.

I thus propose to show that the laws of the universe do not deny the natural aspirations of the human heart; that the progress of society might be, and, if it is to continue, must be, toward equality, not toward inequality; and that the economic harmonies prove the truth perceived by the Stoic Emperor—

*"We are made for co-operation—like feet, like hands, like eyelids, liks the rows of the upper and lower teeth."*

## THE INJUSTICE OF PRIVATE PROPERTY IN LAND

There can be to the ownership of anything no rightful title which is not derived from the title of the producer and does not rest upon the natural right of the man to himself. There can be no other rightful title, because (1st) there is no other natural right from which any other title can be derived, and (2d) because the recognition of any other title is inconsistent with and destructive of this.

For (1st) what other right exists from which the right to the exclusive possession of anything can be derived, save the right of a man to himself? With what other power is man by nature clothed, save the power of exerting his own faculties? How can he in any other way act upon or affect material things or other men? Paralyze the motor nerves, and your man has no more external influence or power than a log or stone. From what else, then, can the right of possessing and controlling things be derived? If it spring not from man himself, from what can it spring? Nature acknowledges no

ownership or control in man save as the result of exertion. In no other way can her treasures be drawn forth, her powers directed, or her forces utilized or controlled. She makes no discriminations among men, but is to all absolutely impartial. She knows no distinction between master and slave, king and subject, saint and sinner. All men to her stand upon an equal footing and have equal rights. She recognizes no claim but that of labor, and recognizes that without respect to the claimant. If a pirate spread his sails, the wind will fill them as well as it will fill those of a peaceful merchantman or missionary bark; if a king and a common man be thrown overboard, neither can keep his head above water except by swimming; birds will not come to be shot by the proprietor of the soil any quicker than they will come to be shot by the poacher; fish will bite or will not bite at a hook in utter disregard as to whether it is offered them by a good little boy who goes to Sunday school, or a bad little boy who plays truant; grain will grow only as the ground is prepared and the seed is sown; it is only at the call of labor that ore can be raised from the mine; the sun shines and the rain falls, alike upon just and unjust. The laws of nature are the decrees of the Creator. There is written in them no recognition of any right save that of labor; and in them is written broadly and clearly the equal right of all men to the use and enjoyment of nature; to apply to her by their exertions, and to receive and possess her reward. Hence, as nature gives only to labor, the exertion of labor in production is the only title to exclusive possession.

2d. This right of ownership that springs from labor excludes the possibility of any other right of ownership. If a man be rightfully entitled to the produce of his labor, then no one can be rightfully entitled to the ownership of anything which is not the produce of his labor, or the labor of some one else from whom the right has passed to him. If production give to the producer the right to exclusive possession and enjoyment there can rightfully be no exclusive possession and enjoyment of anything not the production of labor, and the recognition of private property in land is a wrong. For the right to the produce of labor cannot be enjoyed without the right to the free use of the opportunities offered by nature, and to admit the right of property in these is to deny the right of property in the produce of labor. When non-producers can claim as rent a portion of the wealth created by producers, the right of the producers to the fruits of their labor is to that extent denied.

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: would simply be a change of landlords. Separate ownership merge into the joint-stock ownership of the public. Instead of the possession of individuals, the country would be held by a corporate body—society. Instead of leasing his acres from ..ed proprietor, the farmer would lease them from the nation. . of paying his rent to the agent of Sir John or his Grace, he pay it to an agent or deputy agent of the community. Stewards e public officials instead of private ones, and tenancy the only .ure. A state of things so ordered would be in perfect harmony .e moral law. Under it all men would be equally landlords; all ould be alike free to become tenants. . . . Clearly, there- on such a system, the earth might be enclosed, occupied and ited, in entire subordination to the law of equal freedom."

But such a plan, though perfectly feasible, does not seem to me the . Or rather I propose to accomplish the same thing in a simpler, er, and quieter way, than that of formally confiscating all the land . formally letting it out to the highest bidders.

To do that would involve a needless shock to present customs and its of thought—which is to be avoided.

To do that would involve a needless extension of governmental ..chinery—which is to be avoided.

It is an axiom of statesmanship, which the successful founders of ranny have understood and acted upon—that great changes can best e brought about under old forms. We, who would free men, should heed the same truth. It is the natural method. When nature would make a higher type, she takes a lower one and develops it. This, also, is the law of social growth. Let us work by it. With the current we may glide fast and far. Against it, it is hard pulling and slow progress.

I do not propose either to purchase or to confiscate private property in land. The first would be unjust; the second, needless. Let the individuals who now hold it still retain, if they want to, possession of what they are pleased to call *their* land. Let them continue to call it *their* land. Let them buy and sell, and bequeath and devise it. We may safely leave them the shell, if we take the kernel. *It is not necessary to confiscate land; it is only necessary to confiscate rent.*

Nor to take rent for public uses is it necessary that the State should bother with the letting of lands, and assume the chances of the favoritism, collusion, and corruption this might involve. It is not

necessary that any new machinery should be created. The machinery already exists. Instead of extending it, all we have to do is to simplify and reduce it. By leaving to land owners a percentage of rent which would probably be much less than the cost and loss involved in attempting to rent lands through State agency, and by making use of this existing machinery, we may, without jar or shock, assert the common right to land by taking rent for public uses.

We already take some rent in taxation. We have only to make some changes in our modes of taxation to take it all.

What I, therefore, propose, as the simple yet sovereign remedy, which will raise wages, increase the earnings of capital, extirpate pauperism, abolish poverty, give remunerative employment to whoever wishes it, afford free scope to human powers, lessen crime, elevate morals, and taste, and intelligence, purify government and carry civilization to yet nobler heights, is—*to appropriate rent by taxation.*

In this way, the State may become the universal landlord without calling herself so, and without assuming a single new function. In form, the ownership of land would remain just as now. No owner of land need be dispossessed, and no restriction need be placed upon the amount of land any one could hold. For, rent being taken by the State in taxes, land, no matter in whose name it stood, or in what parcels it was held, would be really common property, and every member of the community would participate in the advantages of its ownership.

Now, insomuch as the taxation of rent, or land values, must necessarily be increased just as we abolish other taxes, we may put the proposition into practical form by proposing—

*To abolish all taxation save that upon land values.*

As we have seen, the value of land is at the beginning of society nothing, but as society develops by the increase of population and the advance of the arts, it becomes greater and greater. In every civilized country, even the newest, the value of the land taken as a whole is sufficient to bear the entire expenses of government. In the better developed countries it is much more than sufficient. Hence it will not be enough merely to place all taxes upon the value of land. It will be necessary, where rent exceeds the present governmental revenues, to commensurately increase the amount demanded in taxation, and to continue this increase as society progresses and rent advances. But this is so natural and easy a matter, that it may be considered as involved, or at least understood, in the proposition to put all taxes on

the value of land. That is the first step, upon which the practical struggle must be made. When the hare is once caught and killed, cooking him will follow as a matter of course. When the common right to land is so far appreciated that all taxes are abolished save those which fall upon rent, there is no danger of much more than is necessary to induce them to collect the public revenues being left to individual landholders.

Experience has taught me (for I have been for some years endeavoring to popularize this proposition) that whenever the idea of concentrating all taxation upon land values finds lodgment sufficient to induce consideration, it invariably makes way, but that there are few of the classes most to be benefited by it, who at first, or even for a long time afterwards, see its full significance and power. It is difficult for workingmen to get over the idea that there is a real antagonism between capital and labor. It is difficult for small farmers and homestead owners to get over the idea that to put all taxes on the value of land would be to unduly tax them. It is difficult for both classes to get over the idea that to exempt capital from taxation would be to make the rich richer, and the poor poorer. These ideas spring from confused thought. But behind ignorance and prejudice there is a powerful interest, which has hitherto dominated literature, education, and opinion. A great wrong always dies hard, and the great wrong which in every civilized country condemns the masses of men to poverty and want, will not die without a bitter struggle.

I do not think the ideas of which I speak can be entertained by the reader who has followed me thus far; but inasmuch as any popular discussion must deal with the concrete, rather than with the abstract, let me ask him to follow me somewhat further, that we may try the remedy I have proposed by the accepted canons of taxation. In doing so, many incidental bearings may be seen that otherwise might escape notice.

## THE PROPOSITION TRIED BY THE CANONS OF TAXATION

The best tax by which public revenues can be raised is evidently that which will closest conform to the following conditions:

1. That it bear as lightly as possible upon production—so as least to check the increase of the general fund from which taxes must be paid and the community maintained.

2. That it be easily and cheaply collected, and fall as directly

as may be upon the ultimate payers—so as to take from the people as little as possible in addition to what it yields the government.

3. That it be certain—so as to give the least opportunity for tyranny or corruption on the part of officials, and the least temptation to law-breaking and evasion on the part of the taxpayers.

4. That it bear equally—so as to give no citizen an advantage or put any at a disadvantage, as compared with others.

Let us consider what form of taxation best accords with these conditions. Whatever it be, that evidently will be the best mode in which the public revenues can be raised.

### *I.—The Effect of Taxes upon Production*

All taxes must evidently come from the produce of land and labor, since there is no other source of wealth than the union of human exertion with the material and forces of nature. But the manner in which equal amounts of taxation may be imposed may very differently affect the production of wealth. Taxation which lessens the reward of the producer necessarily lessens the incentive to production; taxation which is conditioned upon the act of production, or the use of any of the three factors of production, necessarily discourages production. Thus taxation which diminishes the earnings of the laborer or the returns of the capitalist tends to render the one less industrious and intelligent, the other less disposed to save and invest. Taxation which falls upon the processes of production interposes an artificial obstacle to the creation of wealth. Taxation which falls upon labor *as* it is exerted, wealth *as* it is used as capital, land *as* it is cultivated, will manifestly tend to discourage production much more powerfully than taxation to the same amount levied upon laborers, whether they work or play, upon wealth whether used productively or unproductively, or upon land whether cultivated or left waste.

The mode of taxation is, in fact, quite as important as the amount. As a small burden badly placed may distress a horse that could carry with ease a much larger one properly adjusted, so a people may be impoverished and their power of producing wealth destroyed by taxation, which, if levied in another way, could be borne with ease. A tax on date trees, imposed by Mohammed Ali, caused the Egyptian fellahs to cut down their trees; but a tax of twice the amount imposed on the land produced no such result. The tax of ten per cent. on all sales, imposed by the Duke of Alva in the Netherlands, would, had it been

maintained, have all but stopped exchange while yielding but little revenue.

But we need not go abroad for illustrations. The production of wealth in the United States is largely lessened by taxation which bears upon its processes. Ship-building, in which we excelled, has been all but destroyed, so far as the foreign trade is concerned, and many branches of production and exchange seriously crippled, by taxes which divert industry from more to less productive forms.

This checking of production is in greater or less degree characteristic of most of the taxes by which the revenues of modern governments are raised. All taxes upon manufactures, all taxes upon commerce, all taxes upon capital, all taxes upon improvements, are of this kind. Their tendency is the same as that of Mohammed Ali's tax on date trees, though their effect may not be so clearly seen.

All such taxes have a tendency to reduce the production of wealth, and should, therefore, never be resorted to when it is possible to raise money by taxes which do not check production. This becomes possible as society develops and wealth accumulates. Taxes which fall upon ostentation would simply turn into the public treasury what otherwise would be wasted in vain show for the sake of show; and taxes upon wills and devises of the rich would probably have little effect in checking the desire for accumulation, which, after it has fairly got hold of a man, becomes a blind passion. But the great class of taxes from which revenue may be derived without interference with production are taxes upon monopolies—for the profit of monopoly is in itself a tax levied upon production and to tax it is simply to divert into the public coffers what production must in any event pay.

There are among us various sorts of monopolies. For instance, there are the temporary monopolies created by the patent and copyright laws. These it would be extremely unjust and unwise to tax, inasmuch as they are but recognitions of the right of labor to its intangible productions, and constitute a reward held out to invention and authorship. There are also the onerous monopolies alluded to which result from the aggregation of capital in businesses which are of the nature of monopolies. But while it would be extremely difficult, if not altogether impossible, to levy taxes by general law so that they would fall exclusively on the returns of such monopoly and not become taxes on production or exchange, it is much better that these monopolies should be abolished. In large part they spring from legislative commission or omission, as, for instance,

the ultimate reason that San Francisco merchants are compelled to pay more for goods sent direct from New York to San Francisco by the Isthmus route than it costs to ship them from New York to Liverpool or Southampton and thence to San Francisco, is to be found in the "protective" laws which make it so costly to build American steamers and which forbid foreign steamers to carry goods between American ports. The reason that residents of Nevada are compelled to pay as much freight from the East as though their goods were carried to San Francisco and back again, is that the authority which prevents extortion on the part of a hack driver is not exercised in respect to a railroad company. And it may be said generally, that businesses which are in their nature monopolies are properly part of the functions of the State, and should be assumed by the State. There is the same reason why Government should carry telegraphic messages as that it should carry letters; that railroads should belong to the public as that common roads should.

But all other monopolies are trivial in extent as compared with the monopoly of land. And the value of land expressing a monopoly, pure and simple, is in every respect fitted for taxation. That is to say, while the value of a railroad or telegraph line, the price of gas or of a patent medicine, may express the price of monopoly, it also expresses the exertion of labor and capital, but the value of land, or economic rent, as we have seen, is in no part made up from these factors, and expresses nothing but the advantage of appropriation. Taxes levied upon the value of land cannot check production in the slightest degree, until they exceed rent, or the value of land taken annually, for unlike taxes upon commodities, or exchange, or capital, or any of the tools or processes of production, they do not bear upon production. The value of land does not express the reward of production, as does the value of crops, of cattle, of buildings, or any of the things which are styled personal property and improvements. It expresses the exchange value of monopoly. It is not in any case the creation of the individual who owns the land; it is created by the growth of the community. Hence the community can take it all without in any way lessening the incentive to improvement or in the slightest degree lessening the production of wealth. Taxes may be imposed upon the value of land until all rent is taken by the State, without reducing the wages of labor or the reward of capital one iota; without increasing the price of a single commodity, or making production in any way more difficult.

But more than this. Taxes on the value of land not only do not

check production as do most other taxes, but they tend to increase production, by destroying speculative rent. How speculative rent checks production may be seen not only in the valuable land withheld from use, but in the paroxysms of industrial depression which, originating in the speculative advance in land values, propagate themselves over the whole civilized world, everywhere paralyzing industry, and causing more waste and probably more suffering than would a general war. Taxation which would take rent for public uses would prevent all this; while if land were taxed to anything near its rental value, no one could afford to hold land that he was not using, and, consequently, land not in use would be thrown open to those who would use it. Settlement would be closer, and, consequently, labor and capital would be enabled to produce much more with the same exertion. The dog in the manger who, in this country especially, so wastes productive power, would be choked off.

There is yet an even more important way by which, through its effect upon distribution, the taking of rent to public uses by taxation would stimulate the production of wealth. But reference to that may be reserved. It is sufficiently evident that with regard to production, the tax upon the value of land is the best tax that can be imposed. Tax manufactures, and the effect is to check manufacturing; tax improvements, and the effect is to lessen improvement; tax commerce, and the effect is to prevent exchange; tax capital, and the effect is to drive it away. But the whole value of land may be taken in taxation, and the only effect will be to stimulate industry, to open new opportunities to capital, and to increase the production of wealth.

### *II.—As to Ease and Cheapness of Collection*

With, perhaps, the exception of certain licenses and stamp duties, which may be made almost to collect themselves, but which can be relied on for only a trivial amount of revenue, a tax upon land values can, of all taxes, be most easily and cheaply collected. For land cannot be hidden or carried off; its value can be readily ascertained, and the assessment once made, nothing but a receiver is required for collection.

And as under all fiscal systems some part of the public revenues is collected from taxes on land, and the machinery for that purpose already exists and could as well be made to collect all as a part, the cost of collecting the revenue now obtained by other taxes might be entirely saved by substituting the tax on land values for all other taxes.

What an enormous saving might thus be made can be inferred from the horde of officials now engaged in collecting these taxes.

This saving would largely reduce the difference between what taxation now costs the people and what it yields, but the substitution of a tax on land values for all other taxes would operate to reduce this difference in an even more important way.

A tax on land values does not add to prices, and is thus paid directly by the persons on whom it falls; whereas, all taxes upon things of unfixed quantity increase prices, and in the course of exchange are shifted from seller to buyer, increasing as they go. If we impose a tax upon money loaned, as has been often attempted, the lender will charge the tax to the borrower, and the borrower must pay it or not obtain the loan. If the borrower uses it in his business, he in his turn must get back the tax from his customers, or his business becomes unprofitable. If we impose a tax upon buildings, the users of buildings must finally pay it, for the erection of buildings will cease until building rents become high enough to pay the regular profit and the tax besides. If we impose a tax upon manufactures or imported goods, the manufacturer or importer will charge it in a higher price to the jobber, the jobber to the retailer, and the retailer to the consumer. Now, the consumer, on whom the tax thus ultimately falls, must not only pay the amount of the tax, but also a profit on this amount to every one who has thus advanced it—for profit on the capital he has advanced in paying taxes is as much required by each dealer as profit on the capital he has advanced in paying for goods. Manila cigars cost, when bought of the importer in San Francisco, $70 a thousand, of which $14 is the cost of the cigars laid down in this port and $56 is the customs duty. But the dealer who purchases these cigars to sell again, must charge a profit, not on $14, the real cost of the cigars, but on $70, the cost of the cigars plus the duty. In this way all taxes which add to prices are shifted from hand to hand, increasing as they go, until they ultimately rest upon consumers, who thus pay much more than is received by the government. Now, the way taxes raise prices is by increasing the cost of production, and checking supply. But land is not a thing of human production, and taxes upon rent cannot check supply. Therefore, though a tax on rent compels the land owners to pay more, it gives them no power to obtain more for the use of their land, as it in no way tends to reduce the supply of land. On the contrary, by compelling those who hold land on speculation to

sell or let for what they can get, a tax on land values tends to increase the competition between owners, and thus to reduce the price of land.

Thus in all respects a tax upon land values is the cheapest tax by which a large revenue can be raised—giving to the government the largest net revenue in proportion to the amount taken from the people.

### *III.—As to Certainty*

Certainty is an important element in taxation, for just as the collection of a tax depends upon the diligence and faithfulness of the collectors and the public spirit and honesty of those who are to pay it, will opportunities for tyranny and corruption be opened on the one side, and for evasions and frauds on the other.

The methods by which the bulk of our revenues are collected are condemned on this ground, if on no other. The gross corruptions and fraud occasioned in the United States by the whisky and tobacco taxes are well known; the constant under-valuations of the Custom House, the ridiculous untruthfulness of income tax returns, and the absolute impossibility of getting anything like a just valuation of personal property, are matters of notoriety. The material loss which such taxes inflict—the item of cost which this uncertainty adds to the amount paid by the people but not received by the government—is very great. When, in the days of the protective system of England, her coasts were lined with an army of men endeavoring to prevent smuggling, and another army of men were engaged in evading them, it is evident that the maintenance of both armies had to come from the produce of labor and capital; that the expenses and profits of the smugglers, as well as the pay and bribes of the Custom House officers, constituted a tax upon the industry of the nation, in addition to what was received by the government. And so, all douceurs to assessors; all bribes to customs officials; all moneys expended in electing pliable officers or in procuring acts or decisions which avoid taxation; all the costly modes of bringing in goods so as to evade duties, and of manufacturing so as to evade imposts; all moieties, and expenses of detectives and spies; all expenses of legal proceedings and punishments, not only to the government, but to those prosecuted, are so much which these taxes take from the general fund of wealth, without adding to the revenue.

Yet this is the least part of the cost. Taxes which lack the element of certainty tell most fearfully upon morals. Our revenue laws as a

body might well be entitled, "Acts to promote the corruption of public officials, to suppress honesty and encourage fraud, to set a premium upon perjury and the subornation of perjury, and to divorce the idea of law from the idea of justice." This is their true character, and they succeed admirably. A Custom House oath is a by-word; our assessors regularly swear to assess all property at its full, true, cash value, and habitually do nothing of the kind; men who pride themselves on their personal and commercial honor bribe officials and make false returns; and the demoralizing spectacle is constantly presented of the same court trying a murderer one day and a vendor of unstamped matches the next!

So uncertain and so demoralizing are these modes of taxation that the New York Commission, composed of David A. Wells, Edwin Dodge and George W. Cuyler, who investigated the subject of taxation in that State, proposed to substitute for most of the taxes now levied, other than that on real estate, an arbitrary tax on each individual, estimated on the rental value of the premises he occupied.

But there is no necessity of resorting to any arbitrary assessment. The tax on land values, which is the least arbitrary of taxes, possesses in the highest degree the element of certainty. It may be assessed and collected with a definiteness that partakes of the immovable and unconcealable character of the land itself. Taxes levied on land may be collected to the last cent, and though the assessment of land is now often unequal, yet the assessment of personal property is far more unequal, and these inequalities in the assessment of land largely arise from the taxation of improvements with land, and from the demoralization that, springing from the causes to which I have referred, affects the whole scheme of taxation. Were all taxes placed upon land values, irrespective of improvements, the scheme of taxation would be so simple and clear, and public attention would be so directed to it, that the valuation of taxation could and would be made with the same certainty that a real estate agent can determine the price a seller can get for a lot.

### *IV.—As to Equality*

Adam Smith's canon is, that "The subjects of every state ought to contribute towards the support of the government as nearly as possible in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state." Every tax, he goes on to say, which falls only upon rent, or

only upon wages, or only upon interest, is necessarily unequal. In accordance with this is the common idea which our systems of taxing everything vainly attempt to carry out—that every one should pay taxes in proportion to his means, or in proportion to his income.

But, waiving all the insuperable practical difficulties in the way of taxing every one according to his means, it is evident that justice cannot be thus attained.

Here, for instance, are two men of equal means, or equal incomes, one having a large family, the other having no one to support but himself. Upon these two men indirect taxes fall very unequally, as the one cannot avoid the taxes on the food, clothing, etc., consumed by his family, while the other need pay only the necessaries consumed by himself. But, supposing taxes levied directly, so that each pays the same amount. Still there is injustice. The income of the one is charged with the support of six, eight, or ten persons; the income of the other with that of but a single person. And unless the Malthusian doctrine be carried to the extent of regarding the rearing of a new citizen as an injury to the state, here is a gross injustice.

But it may be said that this is a difficulty which cannot be got over; that it is Nature herself that brings human beings helpless into the world and devolves their support upon the parents, providing in compensation therefor her own sweet and great rewards. Very well, then, let us turn to Nature, and read the mandates of justice in her law.

Nature gives to labor; and to labor alone. In a very Garden of Eden a man would starve but for human exertion. Now, here are two men of equal incomes—that of the one derived from the exertion of his labor, that of the other from the rent of land. Is it just that they should equally contribute to the expenses of the state? Evidently not. The income of the one represents wealth he creates and adds to the general wealth of the state; the income of the other represents merely wealth that he takes from the general stock, returning nothing. The right of the one to the enjoyment of his income rests on the warrant of nature, which returns wealth to labor; the right of the other to the enjoyment of his income is a mere fictitious right, the creation of municipal regulation, which is unknown and unrecognized by nature. The father who is told that from his labor he must support his children, must acquiesce, for such is the natural decree; but he may justly demand that from the income gained by his labor not one penny shall be taken, so long as a penny remains of incomes which are gained by a

monopoly of the natural opportunities which Nature offers impartially to all, and in which his children have as their birth-right an equal share.

Adam Smith speaks of incomes as "enjoyed under the protection of the state;" and this is the ground upon which the equal taxation of all species of property is commonly insisted upon—that it is equally protected by the state. The basis of this idea is evidently that the enjoyment of property is made possible by the state—that there is a value created and maintained by the community, which is justly called upon to meet community expenses. Now, of what values is this true? Only of the value of land. This is a value that does not arise until a community is formed, and that, unlike other values, grows with the growth of the community. It only exists as the community exists. Scatter again the largest community, and land, now so valuable, would have no value at all. With every increase or population the value of land rises; with every decrease it falls. This is true of nothing else save of things which, like the ownership of land, are in their nature monopolies.

The tax upon land values is, therefore, the most just and equal of all taxes. It falls only upon those who receive from society a peculiar and valuable benefit, and upon them in proportion to the benefit they receive. It is the taking by the community, for the use of the community, of that value which is the creation of the community. It is the application of the common property to common uses. When all rent is taken by taxation for the needs of the community, then will the equality ordained by nature be attained. No citizen will have an advantage over any other citizen save as is given by his industry, skill, and intelligence; and each will obtain what he fairly earns. Then, but not till then, will labor gets its full reward, and capital its natural return.

# RURAL CREDITS AND CO-OPERATION

By John Cunningham and William M. Brown, Members of the American Commission for the Investigation of Rural Credits and Co-operation in Europe

The modern theory of rural credits and cooperation was conceived and brought to its highest development in Europe. Nearly every European country has some efficient system of agricultural cooperation and rural credits which have been a factor for greater attainments, higher productiveness, a demand for more education, and for better implements and methods. The following articles are taken from the reports of Messrs. Wm. M. Brown and John Cunningham, members of the American Commission which investigated the systems employed in practically all the European countries.

## GERMANY

### RURAL CREDITS

#### *Shulze-Delitzsch Banks*

This system is intended to benefit artisans and tradesmen in the towns, and small employers, and although its business embraces rural credits, it is primarily an urban rather than a rural system. The Shulze-Delitzsch system embraces the Land Improvement Funds, the Land Improvement and Annuity Banks, the Provincial Aid Banks and the Imperial Insurance Institutions, all of which grant loans mainly for urban buildings or land improvement. The area served by the Shulze-Delitzsch Banks is not limited. Shares are high, ranging from $75 to $500. Reserves are not required. Loans are made for short terms. These banks are designed for investments and dividends are often paid. Regular banking offices are maintained, and the business often attains immense proportions. Some banks of this type have an annual turn-over of $100,000,000. Interest rates are higher than those charged by the rural banks.

### *Raiffeisen Banks*

This system of banks founded by Frederick William Raiffeisen in 1849, while of German origin, are not confined to Germany but have been adapted to conditions in nearly all Continental countries. The fundamental idea is, (1) Collective unlimited liability of the members; (2) Restricted area of operation; (3) Free help and management; (4) Promotion of the general welfare of the rural people and betterment of the conditions of rural life.

The Raiffeisen system embraces more than a scheme for rural credits. It is also designed to promote the welfare of the rural people in all other respects. Clergymen and philanthropists are active supporters of these banks and are often cashiers, clerks, bookkeepers, etc. The principal functions of the Raiffeisen Banks are: (1) To meet the needs of their members for incidental personal credit or current working capital; (2) To promote thrift among the rural population by encouraging savings and paying interest on them; (3) To act as the general banker. They are not meant to supply the members with their entire working capital, but to supplement it and supply credit on personal security for productive purposes. Loans are granted frequently for payment on small holdings in some parts of Germany. The Raiffeisen loans to members are carefully safeguarded as follows: (1) Loans are made only to members of the society and only men of character are admitted to membership; (2) Membership is restricted to a small area; (3) Mutual liability is an incentive for each member to see that the borrower makes proper use of the money loaned him; (4) It is to the interest, as well as the policy, of all members to help a member when he is in difficulty; (5) Security is required for such loans; (6) The borrower pledges to use his loan for a specified purpose which he must state when applying for a loan.

Cheap and easy terms for loans on real estate in Germany have been greatly facilitated by a complete compulsory system of land title registration. This system has been widely adopted through Europe. The registers embracing small areas are accessible, free of cost, describe each estate and record all personal charges and incumbrances, and no claim against an estate, if not duly registered, is valid in a court of law.

This system of registration makes possible an accurate computation of the factors that enter into the value of the bonds and result in stability in their values.

## REALTY CREDITS

### *Land Mortgage Credit Association*

Realty Credits are furnished by four groups of institutions: The Land Mortgage Credit Association (Landschaften), the State Provincial and District Mortgage Credit Banks, the Joint Stock Mortgage Banks and the Savings Banks, all of which grant mortgage credit without requiring any statement as to the purpose of the loan.

There are twenty-three land mortgage credit associations. These are borrowers' associations with unlimited liability for procuring loans by the issue of bonds. The bonds of each institution are backed by the collective mortgages held by that institution and by the reserve and sinking fund of the association. They are non-profit seeking organizations and usually have no capital shares. The Prussian associations limit their operations to a single province. The other German states associations usually coincide with their respective states. These associations are considered public corporations subject to state supervision through a Royal Commissioner and their articles of association require the sanction of the Crown or the Minister of Agriculture. They have certain special privileges, such as foreclosure without recourse to the ordinary civil procedure. They are administered by a central board which is subject to the popular control of members through a committee and general assembly. Local representation is a cardinal principle of these associations. None but borrowers are members. Loans are made from $75 and upwards, usually in bonds, which the borrower may dispose of as he chooses. Loans granted by Land Mortgage Credit Associations are for fixed terms. Rates of interest are uniform and do not differ materially from the commercial rates. Annual payments are required until a certain percentage of the debt has been accumulated in a sinking fund, but repayment of any part of the principle may be made at the borrowers' pleasure. Preliminary charges are always low, and well established associations often make none. Administrative charges are small, as the officers usually serve without pay. Cheap and proper safeguards for the association's capital, when loaned, is secured by the fact that the members are conversant with the circumstances of the borrower and self interest is a sufficient incentive to prevent any unwise loan or to notify the institution of any unwise use to which the money is put.

### *Mortgage Banks*

There are sixteen Land Mortgage Banks, all of which, except the Hanover Bank, loan money on urban as well as rural property. The funds of these banks are obtained largely from bond issues, but working capital is provided by deposits, sinking fund accounts, profits, and grants or loans from the state. Bonds are usually redeemed by the banks themselves. Most banks loan money, not bonds, as in the case of the Landschaften. These banks are especially convenient for the smaller land holders, offering them fixed term loans at moderate rates of interest, repayable in annual installments. The present rate of interest ranges from 3½% to 4½%. In addition, there is an annual charge of from ¼% to ½% for cost of administration. From ½% to ¾% sinking fund payments are also required. The borrower may pay his loan by presenting the bonds of the loaning bank. These Land Credit Banks are favored by the state by being exempted from payment of stamp duties and court fees, and to a certain extent of taxes.

### *Joint Stock Mortgage Banks*

There are thirty-seven Joint Stock Mortgage Banks in Germany. These banks are designed not solely for the purpose of aiding the farmers in securing loans on advantageous terms, for they aim to pay dividends. They date back to 1899. They are an association of lenders more or less independent in their operations and unrestricted as to area. Their business is developing rapidly. From 1899 to 1911 their outstanding loans on urban and rural property increased from $387,000,000 to $2,775,000,000. There are two classes—the "pure" and "mixed" mortgage banks. The former, twenty-nine in number, restrict their business to loans on mortgages and the issuing of mortgage bonds. They acquire, sell and loan on mortgage security, make loans to persons and associations for various purposes, including construction work. They purchase stocks and bonds on commission, collect bills and checks and rent safety deposit vaults. Interest is paid on deposits. Speculative business is prohibited.

Joint Stock Mortgage Banks are subject to rigid state supervision. Each bank is assigned a commissioner who, before permitting any bond issue, must certify to the name of the bank officials and that it is properly secured. "Pure" mortgage banks may issue bonds up to fifteen times the amount of their paid up capital and reserves, except

those which had a right to issue in excess of that amount in 1900. A maximum of twenty times paid up capital and reserves is fixed for these excepted bonds. "Mixed" mortgage banks are still further limited. Publicity of the bank's business is required by law, each mortgage bank being obliged to publish in the newspapers not later than February and August of each year detailed statements showing its condition.

### *Savings Banks*

Savings Banks are of great importance in the German realty system. In 1910 their rural mortgages amounted to $850,000,000. The smaller land holders, especially in Western Germany, patronize them extensively. The Department of Agriculture, by constantly urging these institutions to adjust their methods to the convenience of the rural borrowing classes, has been largely responsible for their growth and success. There are certain disadvantages in borrowing from the savings bank, among which are a higher interest rate, instability of the rate and the fact that payment of a loan may be demanded upon notice.

## PERSONAL CREDIT IN GERMANY

### *Agriculture and Co-operative Banking System*

The personal credit system for farmers is an elaborate one. At the head of the system are the German Agricultural Loan Banks and the Prussian State Central Co-operating Banks. The former have twelve branches, each operating over a limited area; the latter are the head of the system made up of the remaining Central Banks in Prussia. The whole Central Bank scheme is designed to accommodate the borrowers of any community as far as possible from the deposits of the same community. These Central Banks are organized by provinces or states. The scheme for furnishing rural credits, involving as it does Central Banks, Local Banks, and Co-operative Societies, with headquarters in Berlin, and affiliated institutions in all the provinces of the empire, involves an immense capital. That of the societies alone in 1910 aggregated $1,310,000,000; that of the Central Banks $2,520,000,000. Loans outstanding amounted to $465,000,000; savings deposits $462,000,000. and check accounts $54,000,000.

### *Local Co-operative Banks and Societies*

Tributary to the Central Bank system above described are about 17,000 local co-operative banks. The membership of these banks is more than one and one-half million persons and represents one-sixth of the agricultural population in Germany. Affiliated with the local banks are 17,668 societies of all kinds, of which 14,508 are credit societies. These rural societies derive 90% of their working capital from deposits of members and non-members residing in their locality. In 92% of the societies liability is unlimited. The societies may not become liable beyond a point of their collective solvency. The result of the success of these societies has been remarkable. It is stated on the best authority that depositors have never suffered a loss. In sixteen years, from 1895 to 1910, inclusive, but nineteen rural credit societies were involved in bankruptcy proceedings. These societies pay from 3% to 4% on deposits. They make a special effort to induce savings among the rural classes by distributing savings boxes, selling savings stamps and cards of various values, and in every possible way endeavoring to encourage thrift. Local classes are able to grant loans to their members at from 4% to 5%. They borrow money when needed from the central banks at varying rates, usually at about 4½% to 5%. They pay a commission of 1/10% to 1/20% on these accommodations. The local societies in loaning out this money charge a commission of 1/10% to ½%. Easy terms of repayment obtain. Terms of the loans are made to suit the convenience of the borrowers. They usually are made for one year, renewable upon application, although they may run two, three, four or five years. These societies reserve the right to call their loans upon notice of one to three months. When arranging for loans, borrowers state the length of time for which they desire the accommodation and the method of payment. They usually repay in installments, spread over a period of years, but have the privilege of making additional payments upon notice of one to three months.

## CO-OPERATION IN GERMANY

### *Co-operative Purchasing*

At first the Raiffeisen societies acted as purchasing agents for the rural communities. Experience proved, however, that they were not adapted to the purpose and a more elaborate system was devised. The

present scheme involved numberless societies, many of which co-operate, forming still more societies and help to make up a great system which covers whole provinces. Thus a supply association of German farmers is made up of and acts as the agent of large agricultural societies. The central association purchases for the various societies vast quantities of commodities, securing preferential rates as a result of their large purchases. Six hundred twenty thousand tons basic slag for fertilizer were purchased in one year. In general, the co-operative societies embrace two groups: The Imperial Federation and the Raiffeisen or General Federation. Membership in the Imperial Federation is open to unions and societies organized for co-operative purposes. The Raiffeisen Federation has been affiliated with the Imperial Federation and at present includes four-fifths of the total registered co-operative societies in its membership. The grand total of members in all societies is 1,900,000. This federation is active in promoting the general interest of its members, paying especial attention to uniform system of audits, and to insurance and dispensing legal advice. Co-operative societies in Germany are required to be registered in the court of the district in which the society is located. Each society must comprise not less than seven persons, must state as its object the furtherance of the economic interest of its members and must have written articles of association. Each society has a committee of management of two members and a board of supervision of at least three members, both of whom are elected by the members. Each member must purchase a share, usually paying one-tenth in cash. Reserves are formed out of the profits. Each society must publish its balance sheet annually.

### *Co-operative Production*

There are 3,200 registered societies and nearly 800 unregistered societies in Germany. Their sales amount to $100,000,000 annually. Co-operation in this industry has brought about a more thorough utilization of raw material, standardization of quality and better prices. The beneficial effects of co-operative effort in this line have been particularly noticeable in the improved quality of the stock.

### *Dairy Societies*

There are three types of dairies. First, those separating the cream, making butter and returning the skimmed milk to the members;

second, those which sell the new milk or utilize all of it; third, cream depots which separate the cream and send it to a central dairy in a neighboring town. The second of these is not common. More skilled labor and capital are needed. From three to four hundred cows are necessary to start a dairy society. Members must deliver all milk produced except what is used on the farm. Milk is sometimes gathered by the societies or delivered by the individual members. In the small holdings districts the societies gather the milk, employing members in various sections to bring it in. Payment is usually for butter fat. Sometimes, however, it is made on a basis of quantity, in addition to which a further payment is made based on butter fat contents. Three or four tests per month are made for butter fat and members are paid according to these tests. Co-operative milk selling societies have been established to send milk to a central cooling station or central sales station. The object of the society is to encourage production of pure milk and obtain the advantage of a higher price for a guaranteed quality.

### *Grain Selling Societies*

State aid has been furnished in several of the German States to promote Co-operative Grain Selling Societies. The ends sought are (1) improved facilities for cleaning, drying and grading; (2) better prices by adjusting the supply to the demand; (3) making it possible for farmers to obtain credit upon their grain as collateral; (4) cheapen the cost of production and distribution. These societies sell between two and three million hundredweight anually.

### *Egg Selling Societies*

Germany imports $40,000,000 worth of eggs annually. To take advantage of the large demand, about one hundred and fifty egg selling societies are registered and many unregistered societies exist, while many dairies and other societies sell eggs as a side line. Beside the regular business of grading and delivering eggs promptly to the market, thereby guaranteeing the high standard of quality, these societies have done much to promote the breeding of high grade fowls by selling to their members pure breeds at low prices.

### *Co-operative Electrical Societies*

There are three types of Co-operative Electrical Societies. First, those purchasing and distributing electricity; second, those owning their own plants but buying their supplies from others; third, combinations of persons agreeing to purchase a specified amount of electricity in order to get it at reduced rates. The last class predominates. As a result, cheap electrical power is obtained by the small farmers. In many sections, rural districts and communities have erected electrical works or have been partners in such undertakings.

### *Other Societies*

Machine purchasing societies often buy expensive machinery, like threshers, rollers, grist mills, pressing machines, etc., and let them to the individual for small rental. Threshing machines are located in a permanent place and small farmers bring their grain there, where it is threshed and the straw baled, the wheat delivered to the elevator, the straw carried back for bedding, etc.

Distilling societies, for the manufacture of spirits from potatoes, have been organized. Potato drying societies are a recent addition. Breeding societies obtain the best breeding stock, give advice on breeding questions and on markets and establish and keep herd books usually in conjunction with their local societies. They are encouraged and aided in most of the states by the official and semi-official agricultural bodies.

## DENMARK

### RURAL CREDIT

Denmark is an agricultural country and specializes in butter, bacon and eggs. Its financial institutions have been adapted to meet the needs of the farmers. The savings and commercial banks have met the credit demand so well that rural credit societies have been unnecessary. Four per cent is paid on deposits and 5% charged on loans. These banks are under rigid government inspection. A simple land title register makes real estate values easy to ascertain. A peculiar feature of the savings banks is a reverse fund made up from profits and devoted to benevolent purposes.

## CO-OPERATION

### *Dairies*

Intensive farming in Denmark has resulted in abandoning the culture of grain for that of higher priced products, especially butter. Co-operative dairies organized as early as 1882, by private initiative, predominate, and to these dairies the progress in the production of butter is due. Each member has one vote irrespective of the amount of milk furnished. The co-operative dairies are combined in a series of central federations for the purpose of buying supplies, providing lectures, disseminating desirable agricultural information and promoting exhibitions. "Juries" organized for the purpose of testing the purity of milk and encouraging the production of better butter are associated with several unions. Milk was formerly bought by weight, but is now paid for on butter fat content. Rigid economy is practiced. One example was noted; the animal drainings from emptied milk cans placed upon a rack yields an income of $20. The Federation of Dairies have a society for export only, which devotes itself, independent of merchants, to the sale of butter.

### *Hog Products*

Bacon production ranks next in importance to that of dairying. Live pigs were exported to Germany until that country prohibited it in 1888. In order to take care of the home product, eight bacon factories were established. In a short time Germany repealed the law prohibiting the importation of live pigs from Denmark, and heavy shipments followed. Germany renewing the embargo in 1895, the Danes again resorted to bacon factories, and today these institutions number thirty-four, with a membership of 95,000, with an annual slaughter of over a million pigs, this being more than two-thirds of the number raised annually in Denmark. The bacon is mostly exported to England. Differing from the dairy industry, members of the bacon factories association are men of large land holdings. No evidence was produced that the organization and government of these societies differ from other organizations of a co-operative nature.

### *Eggs*

From 550 local centers eggs are collected and turned over to ten packing stations. Nearly 20% of the total egg production is han-

dled in this way. This system beginning in 1895, with a few hundred members, has grown to a membership of over 40,000. From each local center a collector makes the rounds of his district once a week. Producers must gather the eggs each day. All eggs are candled and stamped with the trade mark of the export society and the number of the station and the farmer. Defective eggs can thus be traced to the producer, and for the first offense he is warned, for the second, fined, and for the third, expelled. All eggs are bought and sold by weight. Instead of cold storage, a liquid preparation, which is a trade secret is used to preserve the eggs. The co-operative egg societies take active steps to increase the quantity and quality of the product. Experts are furnished to discuss poultry culture with the farmers. Prizes are given for the best laying hens.

## Education

The Danes remodeled their educational system by making it thoroughly vocational in character. The people being largely rural, the whole bent of education is toward agriculture. Agricultural high schools, dating back to 1864, organized under private initiative with governmental aid, not to be confused with our high schools, dot the whole country, and to these schools is given the credit for the change in the life and spirit of the Danes. They are patronized by grown people who have finished the secondary schools. They offer summer courses for women and winter courses for men. Instruction and maintenance for each pupil for the five months' winter course is $55.00. The cost of the three months' summer course, including tuition and maintenance, for women is $30.00. These schools are popular and register more than 10,000 students annually. The winter schools have special courses for men and women laborers who want to become farmers, and oral instruction plays an important part in these courses. No effort or time is spent on subjects which do not have a practical value. The government encourages agricultural education through liberal legislative and financial aid, and has been influential in converting its population into home owners. The larger percentum of the holdings are from 36 to 76 acres, and the productivity of the country is great. From 60% to 70% of the legislators are farmers.

## RULES FOR THE CONDUCT OF BUSINESS OF A CO-OPERATIVE EGG SELLING SOCIETY (HANOVERIAN CHAMBER OF AGRICULTURE)

### Registered Society With Limited Liability

Section 1. The business must be conducted with the limits of the objects of the undertaking, which consists in the sale in common for profit of the eggs delivered by the members.

Sec. 2. The handling and delivery of eggs at the collecting station is regulated as follows:

(*a*) Every member is obliged to deliver the whole of the eggs produced on his farm with the exception of those required for his own use or for the purpose of breeding, at the collecting station designated by the committee.

(*b*) The collecting station shall only receive such eggs as have been produced on the farms of the members.

(*c*) Eggs, which in summer are more than three days (four days) or in winter more than six days (eight days) old, must not be delivered. They are to be used on the member's own farm, inasmuch as such eggs have no longer any title to be called fresh eggs, and can prejudice the reputation of co-operative egg selling.

(*d*) The holding back of eggs, in order to make a subsequent delivery at the collecting station is not permitted.

(*e*) The eggs must be taken daily from the nests and kept in a cool well ventilated place until the time of delivery. Eggs which have been also for one day only under a sitting hen must not be brought to the collecting station. Porcelain eggs are to be used as nest eggs. The eggs delivered must be clean and free from attached dirt. Dirty eggs will be rejected at the collecting station. In order to make the production of clean eggs possible, the cleanliness of the hen-roosts and of the nests should be especially kept in view.

(*f*) All eggs must be stamped. Egg stamps are furnished by the society, and each member must pay for the stamp assigned to him. The stamps remain the property of the society, and must on cessation of membership be returned to the society. If the stamp is still fit for use, a sum equivalent to the value of the stamp will be refunded. Every stamp bears the trade mark which the Chamber of Agriculture has registered, and, further, the device of the club or society, ex-

pressed by certain letters, and the number by which the member is registered in the egg receipt book.

(*g*) Every egg is to be examined at the collecting station by an egg lamp or some other suitable egg tester. Eggs that fail to pass the test will not be reckoned as delivered.

(*h*) Rejected eggs shall be indicated at the collecting station by a special mark.

(*i*) Payment for eggs is made either by number or by weight. If paid for by number, eggs of a less weight than 45 grammes (50 grammes) are not to be delivered (57 grammes 2 ozs.).

(*j*) If a member infringe the regulations that only fresh and sound eggs shall be delivered, a deduction shall be made from the payments due to him of ........ pence for each bad egg so delivered.

(*k*) If a member is proved to have sold eggs to a merchant or to some other person directly, he must pay a fine of .......... shillings.

(*l*) Repeated infractions of the regulations as to the delivery of eggs may be punished by the expulsion of the member involved by the society.

(*m*) It is the duty of the person in charge of the collecting station to draw the attention of members to any defects in the eggs delivered.

Sec. 3. For the conduct of the business of the society, a manager shall be appointed by the committee, who, under the instruction and guidance of the committee, shall carry out the duties imposed upon him in a conscientious manner.

Sec. 4. The position of the manager shall be regulated by contract.

Sec. 5. The committee shall furnish the manager with the necessary funds for carrying on the business, and is responsible for its use for the purposes intended.

Sec. 6. The manager shall keep the necessary books of the society in an orderly manner, and make the entries of eggs received in the proper books.

He shall further take care that the eggs are handled and packed in an expert fashion, and, above all, he shall see that only fresh and odorless packing material is used.

The eggs must be packed in a clean, light and well-ventilated room, in which no malodorous material shall lie.

In consideration of the fact that the eggs, from the moment of delivery to that of despatch, may lie in the packing room at least one

and frequently more days, this room must be in a cool situation.

The manager shall be responsible for loss sustained by the society through neglect of these regulations.

Sec. 7. The bookkeeping shall be carried out on commercial principles. The following books are to be kept: Eggs received, eggs despatched, egg ledger and egg journal. In large societies a ledger for debtors and creditors must be kept in addition.

Every member shall receive a small account book in which the manager enters at each delivery the number of eggs received. In agreement with this a corresponding entry must be made in the eggs received book.

The account book bears the name of the member to whom it is issued; in addition, an impression of the egg-stamp, showing the member's number.

Sec. 8. Accounts shall be made up monthly. Members may receive the amount due for eggs delivered in the previous month after the 10th of each month; on request, and, with consent of the committee, payments on account may be made. The price to be paid for the eggs shall be established by deducting the monthly expenses and an amount representing the cost of general maintenance from the total receipts for eggs. The accounts shall be made up by two members of the committee, or, in case of their inability, by other members nominated by the committee, together with the manager.

The manager shall previously prepare the statement of accounts by calculation of the quantities of eggs delivered.

The manager shall receive, as remuneration for bookkeeping, paying out of monies, preparation of the year's accounts, receiving, packing and despatch of eggs, a sum based on a percentage of the turnover; the percentage to be fixed beforehand by the committee at the beginning of the year.

Sec. 9. Should one collecting station not suffice, further stations may be set up within the district covered by the society, from which the eggs shall be sent to a special central station. For the temporary storage of eggs in the sub-stations the regulations of section 6 shall hold good.

The conduct of business in the sub-stations shall be governed by regulations specially drawn up by the society.

# LAWS AND CONSTITUTION OF CO-OPERATIVE MORTGAGE BANKS OF DENMARK

## General Rules

1. *The Object of a Mortgage Bank.*—A mortgage bank is a company composed of landed proprietors (from the Danish-speaking provinces of the Kingdom of Denmark), founded with the sanction of the King with a view to making it easier for the members of such a company to borrow money upon easy terms upon the mortgage of their estates, and by degrees to repay the sums thus borrowed.

2. *Right of Membership.*—Every owner of a piece of land situated in one of the seven Danish provinces, which land after due investigation is valued at least at $324 can join the company.

3. *Admission to Membership.*—Any land owner who wishes to become a member of a mortgage bank must mortgage some of his property to that bank, and first he must send to the directors an application worded according to the form set forth in Appendix 1 and signed by himself. Such an application must be accompanied by documents affording information as to the property to be mortgaged, such as:

(1) Certified extracts from the register of mortgages, and certificates as to all mortgages, taxes, and charges upon the property.

(2) Authorized extracts from the domesday book at present in force and, if possible, from the later one which has not as yet been published, as well as documents showing the usual price or farming rent of an acre in the neighborhood.

(3) Conveyance and certified extracts from documents connected with the division of property (e. g., wills and marriage settlements).

(4) Ordinary farming leases and perpetual leases,[1] together with a faithful calculation of the annual profits and losses on the farms based upon a 10 years' average.

(5) Old books of accounts, housekeeping books, and a description of the property and the method of farming it.[2]

[1] Such leases, called faeste, are found in Denmark.

[2] The laborers are boarded and lodged on Danish farms; hence the importance of the housekeeping books.

(6) Fire insurance policies and similar documents.

(7) If there are other mortgages upon the property, a declaration in legal form from the mortgagee that he will accept the payment of the debt either in mortgage bonds or in cash. The owners of entailed estates must show that they have permission from the King to mortgage their estates.

4. *The Issue of the Mortgage Bonds.*—A landowner becomes a member of the bank when he delivers to its cashier a mortgage upon his property, drawn up in the form contained in Appendix 2, and receives his loan in the shape of the bank's debentures. In the form already mentioned the obligations of the mortgagor toward the bank are carefully defined.

5. *Minimum of Loan.*—No loan under $50 will be granted.

## Section II—Mortgage Bonds

6. *The Form and Value of Mortgage Bonds.*—Mortgage bonds are hypothecating debentures provided with interest coupons and payable to bearer, which are issued by the directors of the bank on the security of all the mortgages affected with them by the different members of the bank. Mortgage bonds which can be registered in the company's books in the names of the proprietors are issued for the following amounts, viz., $3, $12, $60, and $120. Appendix 2 contains a form for a mortgage bond.

7. *The Security for the Principal and Interest of the Mortgage Bonds.*—The sum total of all the mortgages effected by all the members forms the security upon which each one of the mortgage bonds is based. There is no assignment of a particular mortgage as security for a particular mortgage bond.

8. *The Payment of Interest.*—The interest on the mortgage bonds will be paid to the bearers of the coupons on delivery. The yearly payments are made on January 1, April 1, July 1, or October 1. The interest can only be drawn at the head office at Copenhagen or at the other places named on the mortgage bonds.

9. *The Consequences of not Claiming the Interest at the Right Time.*—If the bondholder does not draw his interest within three months after the day of payment, he will be unable to claim it until the following pay day, and the compound interest due upon it will go to the reserve fund.

10. *The Right of the Bondholders to Have Their Bonds Cashed.*

—Bondholders can have their bonds cashed on giving six months' notice. The face value of the bonds will then be paid out of the sinking fund, alluded to in the third section of these rules, in the order in which notice is given. Should the total amount of the demands for cash in exchange for the bonds exceed in the course of one year the amount of the sinking fund and of the other funds at the bank's disposal, the latter demands for cash will be attended to in the following year. This will be carried out in such a manner that the latest date when such bonds can be redeemed will be announced each time that a customer gives notice of his intention of cashing his bonds. When such notice is given the holder hands over his bond to the company, which gives him a receipt, on showing which the bearer can have the amount of the bond paid to him in ready money at the appointed time.

11. *The Company's Right to Withdraw from Circulation and Redeem Its Bonds.*—The company can redeem its bonds on giving six months' notice. A number of bonds are, as mentioned in paragraph 17, drawn out every year for the purpose of redemption. In such cases the announcement in the newspapers of the numbers drawn must be accepted in lieu of a notice. In like manner, bondholders cannot require that notice of the redemption of bonds should be published otherwise than through the newspapers.

12. *Regulations with Regard to Bonds Which Have Been Lost.*—The amortization of coupons or bonds which have not been registered cannot take place. Anyone who furnishes proper proof of having accidentally lost a bond or the coupons attached to it can, however, have paid to him the value of such a bond or coupons when 20 years have elapsed without having made their appearance.

### Section III.—The Repayment of the Mortgage Debt

13. *Contributions to the Sinking Fund.*—Besides the interest on the mortgage bonds and a contribution toward the expenses of management, members of the company must repay each year during 47 years three-fourths of 1 per cent of the loans which they have taken up, so that the same will be paid off by degrees within the period above named by means of a sinking fund.

14. *The Repayment of Larger Yearly Installments During a Shorter Period.*—Every member of the company is free to repay a larger amount each year than is mentioned in the last paragraph, thus proportionally shortening the period during which he has to pay interest.

15. *The Repayment of Smaller Yearly Installments During a Longer Period.*—The repayment of smaller yearly installments than are mentioned in paragraph 13 will only be permitted by the directors under special circumstances.

16. *The Gradual Repayment of the Total Amount of the Debts Bonds.*—The repayment of all the debts of the company is carried out by means of the gradual redemption of the bonds issued by it and of its interest coupons. The carrying out of such a redemption is dependent upon the amount of the sinking fund.

17. *The Drawing Out of Bonds to Be Redeemed.*—When the total amount of the bonds, notice of whose redemption has been given in the course of any single year, does not equal the amount of the sinking fund, it is decided which bonds are to be redeemed by drawing out. The result of the drawing is made known in the public prints at least six months before the time of payment. At the end of the quarter when they are paid the bonds cease to bear interest.

18. *The Repayment of a Fixed Sum as a Special Installment.*—When the debtor pays a fixed sum as a special installment (which during the three first years after receiving the loan must not amount to more than half the loan), he can choose between two courses. Either he can contribute a proportionately smaller amount in repayment of principal and interest during the same period, as was originally fixed; or he can continue to contribute the same sum as heretofore in repayment of capital and interest, and thus be freed from his debt in a shorter time.

19. *The Transformation of the Remainder of a Debt Into a New Loan.*—When a debtor has repaid part of his loan by means of a sinking fund, he may, with the permission of the directors have the remainder of his loan re-entered under a new heading. He then begins again from the beginning to amortize his debt, repaying interest and capital upon it, as though it were a new loan.

20. *The Taking Up of a New Loan of the Same Amount as That Portion of the Old Loan Which Has Been Paid Off.*—With the directors' leave a debtor may take up a new loan equal in amount to the portion of the old loan which he has paid off. In such a case his old account must be closed and a new one opened. The amortization of the new loan must begin from the beginning. He must repay in ready money any debt standing against his name in the books of the reserve fund (see par. 25), and the directors have the right to demand a fresh valuation of the property mortgaged with a view to proving

that its value has not decreased since the previous valuation.

21. *The Minimum Size of the Installments.*—The size of the installments paid by the debtor when he adopts the first of the two alternatives mentioned in paragraph 18 must not be less than 11 pounds. When he adopts the second alternative the sum repaid must be sufficiently large to enable him to advance the process of amortization by at least one year. Small sums may be accepted in prepayment of interest. In such a case the debtor is compensated for the payment of interest upon that sum during the period preceding the day when it would otherwise fall due, provided that the sum amounts to more than 3 pounds and the period is longer than six months.

22. *Notice to Be Given of the Payment of an Installment.*—Notice of payment of an installment must, for the reasons mentioned in paragraph 11, be given to the company six months beforehand, provided that the payment is not made in the form of bonds, upon which both their value at par and interest until the day of payment must be credited to the payer.

## Section IV.—The Reserve Fund

23. *The Object of the Reserve Fund.*—The object of the reserve fund is to insure the company against losses which it may incur in the case of individual members and against the occurrence of unforeseen expenses which the management might be unable to meet.

24. *The Sources of Income of the Reserve Fund.*—The reserve fund derives its income from the following sources:

(1) The revenue which accrues to the company each year owing to the fact that its debtors pay their interest every half year, while its creditors have it paid to them only once a year (par. 8, 27).

(2) The remainder of the yearly payments made by borrowers, with a view to covering the expenses of management.

(3) The interest upon the interest not drawn by bondholders within three months of quarter day and which consequently is not paid before the following quarter day. (Par. 9.)

(4) The amount of the value of lost and destroyed bonds and coupons to the ownership of which none has established his right. (Par. 12.)

(5) The interest and compound interest upon the bonds which have been purchased with the monies accruing to the reserve fund, and which have not again been sold (before they yielded interest) in order

to cover the expenses of the reserve fund.

(6) Any other sums received by the company.

(7) Loans which the directors are entitled to contract in order to cover the expenses of the reserve fund. The security for such loans is to be the revenue derivable from the right of the directors to demand that members of the company should continue for three years after their debt is paid off to pay the same amount to the company as they had paid before in installments of capital and interest.

25. *Balancing the Reserve Fund.*—Any difference between the assets and liabilities of the reserve fund at the end of the year is proportionately divided among all the members of the company, being entered upon the credit or debit side of the account of each member in the company's books. By comparing the assets and liabilities of each member year by year, it is easy to ascertain what amount members may claim, after repaying their mortgage debt, or in cases where their liabilities exceed their assets, how long they must continue to pay the same sum as they have been paying in capital and interest.

## Section V.—The Duties and Rights of Borrowers

26. *The Yearly Amount Payable by Members.*—Members of the company must pay a yearly amount made up of 4 per cent interest on the bonds, three-fourths per cent for amortization, and one-fourth per cent for expenses, making altogether 5 per cent per annum. Their debts to the company are thus gradually paid off in the course of 47 years. (Par. 13.)

27. *The Times and Places for the Payment of Interest.*—The interest mentioned in the last paragraph is paid twice a year in advance upon certain days. These days may, at the choice of the debtor, be February 15 and August 15 or May 15 and November 15. When the bonds are not delivered to him upon one of these days, the debtor must pay interest in ready money for the time which has to elapse until the next pay day immediately upon receiving the bond. This to insure that the interest is prepaid upon the appointed day. Payment must be made in current coin and without deductions at the head office at Copenhagen or at some other place appointed by the directors.

28. *Proceedings in Case of Failure to Pay Interest.*—As the whole existence of a mortgage bank and the due fulfillment of its obligations depend upon the punctual payment of interest, the pay-

ment of the latter must be enforced with the utmost strictness. If a debtor fails to pay the interest due from him within the appointed period, such interest will 20 days after it falls due be taken up as a loan by a business house at the expense of the debtor, and the arrangements will at once be made for his prosecution. When the directors have had three times to enforce by legal means the payment of interest, they are entitled, in accordance with paragraph 30, to demand repayment of the rest of his loan from the defaulting debtor.

29. *On Leaving the Company.*—Members of the company can leave it, provided that five years have elapsed since they joined it, and that they repay the remainder of their loans, as well as any debts standing against them in the books of the reserve fund. (Cf. par. 25.)

30. *Compulsory Repayment of a Debt.*—Mortgages can not as a rule be foreclosed by the company. The directors can, however, demand from a borrower, on giving him three months' notice, the repayment of the rest of his debt, under the following circumstances:

(1) When the company has twice had to use legal means to compel him to pay his interest.

(2) When, owing to a sale, a division of property, etc., the debt has been divided up among a number of individuals in such a way that no single part of it is equal to 110 pounds.

(3) When the directors find that owing to bad management the value of the property mortgaged has been diminished by a quarter and no longer affords the necessary security. With regard to the reserve fund the same rules are in force with regard to the compulsory payment of a debt as have been set forth in the above paragraph with regard to its voluntary payment.

31. *The Sale of the Security.*—When a debtor after receiving due notice cannot repay his debt at the appointed time, the directors may insist upon the sale of the property mortgaged with a view of satisfying their demands.

32. *No Dilatory Legal Proceedings to be Employed.*—Borrowers pledge themselves not to take advantage of any dilatory forms of legal procedure with a view of delaying execution. They undertake to submit to summary proceedings for the liquidation of their debts to the company.

33. *The Debtor's Account.*—Every debtor on leaving the company is given a statement of accounts, by means of which he can ascertain among other things how his debt has gradually been extinguished.

## SECTION VI.—THE SECURITY

34. *The Liabilities of the Property Mortgaged.*—The property mortgaged by each of the landowners belonging to the company is pledged for the fulfillment of his obligations with regard to the loan which he has received and also for the covering of any expenses which the directors may incur in enforcing by legal means the repayment of the said loan.

35. *The Amount of the Security.*—As landowners can only borrow up to three-fourths of the value of their property, the latter must always exceed in value by one-fourth the amount of the loan.

36. *The Security Must Produce a Net Yearly Income.—The Size of Such an Income.*—In order to insure the reception by the company of the yearly payments due from its debtors, the security must produce a fixed net income, which must exceed the total of the yearly payments to be made by the borrowers to the company by at least one-third. This calculation is based upon the ordinary payments, even if the debtor has undertaken to pay a larger contribution than usual with a view to the more rapid extinction of his debt. Property which does not produce a net revenue, such as splendid private residences, can only be included in the valuation at the price which it would probably fetch in the event of a sale. It cannot be accepted as a security.

37. *The Valuers.*—The general meeting will appoint from 8 to 12 of its members in each province as valuers. They are sworn in once for all and carry out their duties for five years, after which they may be selected again. When a landowner gives notice to the directors of his wish to take up a loan, and the latter consider a valuation of his property necessary, they chose three of their valuers, intrust to them the necessary power and hand over to them the documents regarding the value of his security sent in by the borrower in accordance with paragraph 3. The valuers are not bound to base their estimate upon the aforesaid documents or upon any former valuation, but they may found their estimate upon any basis which is likely to help them to form an opinion as to the real and permanent value of the property, provided that they do not go beyond the instructions given them by the directors.

38. *Buildings in the Country as Security.*—Buildings in the country to which no land is attached cannot be accepted as security. On any case not more than a quarter of the total value of the property

mortgaged may be made up of buildings. No building may form part of a security unless it is insured against fire.

39. *The Calculation of Net Revenue Derivable from Buildings in the Country.*—When calculating the net income produced by a country property, the necessary dwelling houses and agricultural buildings must be valued at 1 per cent of the amount for which they are insured against fire. Castles, large private residences, and other buildings which produce no revenue cannot be taken in consideration when estimating the net income yielded by a property. Inns, distilleries, and mills situated in the country having agricultural land attached to them may be valued at a percentage of the sum for which they are insured against fire, which percentage will be fixed in accordance with circumstances.

40. *Woods as Security.*—In case of mortgages effected by private individuals woods may not make up more than a fifth part of the valuation, and only woods belonging to communes or public institutions may be accepted by themselves as security. The mortgagor must, however, expressly pledge himself to preserve and treat scientifically the woods mortgaged even in cases where the regulations of September 27, 1805, have been suspended, and the owner is free to treat his woods as he will. The valuation of woods is based upon the value of the land, the local prices of timber, the way in which the particular wood has been treated, and the opportunities afforded for the disposal of its products. In the case of forests covering an uninterrupted area of more than ——— acres, a scientific valuation must be made by a royal forest officer, and examined by his immediate superior, who will certify in writing that no objection can be made to the valuation.

41. *Fines, Tithes, Corvee Money, and Similar Payments as Security.*—Fines, tithes, payments in view of forest labor, and other similar fixed yearly payments must as a rule not amount to more than half the valuation of the property mortgaged. In no case must their capital value be estimated at more than twenty times their yearly amount after all deductions and charges have been subtracted from it. Payment in view of forest labor and tithes, when both of them are paid in kind, are included in the valuation.

42. *The Variable Income of a Property as Security.*—In the case of payments of varying amount and incidence, such as fines on succession to hereditary leaseholds, etc., extracts from the books in which such payments have been entered during the previous 10 years. Such payments after the deduction of all charges may not amount to more than a quarter of the net revenue.

43. *Pasture, Shooting, and Fishing Rights as Security.*—Pastures must not as a rule contribute more than a sixth part of the value of the mortgage. Shooting and fishing rights and all similar sources of income can only be taken into consideration when a valuation based upon the net income derivable from them shows them to have a capital value of more than 110 pounds.

44. *Combinations of Various Things Accepted as Securities Only Under Certain Conditions.*—When several things are to be mortgaged, which according to paragraphs 38, 40, 41, 43 can each only form part of the value of the mortgage, it is for the directors to determine how large a proportion of the separate values of the property mortgaged may be made up of the total value of all the above things.

45. *The Deduction of Rates, Taxes, and Other Charges, as Well as of the Cost of Management.*—In calculating revenue rates, taxes and charges of all kinds must be shown in the statement and deducted. In the case of large properties and revenues, which are not formed by others, the amount of the expenses of management during the previous 10 years must be shown, and the yearly average of such expenses must be deducted from the net income. In the absence of such a calculation the expenses of management will as a rule be reckoned at a tenth part of the net revenue.

46. *The Valuation of Payments in Kind.*—In all calculations based upon payments in kind the latter must be valued according to the average prices of the last 20 years, leaving the two years in which the prices were highest and the two years in which they were lowest out of the calculation of averages.

47. *Instructions to Valuers.*—Besides the hints with regard to the determination of the value and income of a property given here for the mortgagors' benefit, comprehensive instructions are issued to valuers, in accordance with which those to whom the directors commit the task of valuing the property (par. 37) have to act, so as to insure that the valuation is made in accordance with certain fixed principles.

48. *The Company Must Always Have the First Mortgage.*—The security must not be subject to any mortgage taking precedence of that of the mortgage bank. If such a mortgage exists, the mortgagee must be paid off at the expense of the mortgagor by the company either in ready cash or in bonds of a like amount, provided that the mortgagee does not make a legal declaration to the effect that he will give up his first mortgage and content himself with a second mortgage in accordance with the demands of the company.

49. *A Third Party's Property as Security.*—In exceptional cases a third party's property can, with his consent, given in legal, form, be accepted as a security.

50. *Redemptions During the Duration of Mortgage.*—If a redemption of yearly charges, such as corvee money, tithe, etc., takes place during the duration of a mortgage, the sum thus realized must be lent to the mortgage bank at the same rate of interest as is paid upon the bonds, until such time as the mortgage can be taken off the register, unless the landowner prefers to employ the above-mentioned sum in paying off his debt to the company.

51. *The Swearing in of the Bailiff or Manager.*—In the case of important loans taken up by private individuals, the company may request the bailiff or manager of the property to swear to use the revenues of the property first of all to satisfy the demands of the mortgage bank with regard to the annual payment connected with the loan.

52. *Papers to be Produced When Money is Lent to Public Bodies.*—In the case of loans to communes and public institutions, proof must be furnished of the consent of the authorities to the contracting of such a loan. This may be done by the production of a certified duplicate of the decree by which the loan was authorized, as well as of a properly certified balance sheet showing the revenue, expenditure, property, and liabilities of the commune or public institutions.

53. *The Issue of Certificates.*—Statements sent in to the mortgage bank must be certified by authorities using public seals or officials who are not employed by the borrower. Officials who use public seals need not, when sending statements to the company in the course of official business, have the latter certified by other authorities, but may themselves issue the necessary certificate.

54. *The Partial Liberation of the Security.*—The directors of the company in exceptional cases may, when it can be done without injurying the company, free the property mortgaged from a portion of the liability corresponding to the amount of the debt which has been paid off in the course of amortization. This must not, however, be regarded as creating a precedent.

55. *A Change of Securities.*—The directors may accept a security of equal value in the place of the one originally offered.

56. *Change of Owners of the Security.*—When the liabilities of a mortgagor are divided among several persons owing to a sale or for some other reason, such persons assume joint responsibility with

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a decision. Members can vote by proxy, provided that the holder of the proxy is a member of the company and that he does not vote by proxy for more than one person.

60. *The Management in General.*—The board of directors consists of four members chosen every fifth year by the general meeting. The members of the general meeting are quite unfettered in their choice of directors, and need not choose them from among the members of the company. Former directors can be re-elected. The four members who receive the highest number of votes after those chosen as directors become their deputies. As such they join the board whenever its number is incomplete, owing to the absence of any of its members, or whenever the directors consider an increase in their number desirable. The resolutions of the directors are decided by vote. Three members must be present in order that a resolution may be valid. Besides the four directors the general meeting chooses a lawyer well acquainted with all matters appertaining to mortgage banks as the representative of the bondholders and assigns him a salary of ——— pounds, to be paid out of the management fund. He must see to it that nothing is done to prejudice the interests of the bondholders. He has a seat and a vote at all directors' meetings and the right to veto the carrying out of any resolution of the directors which seems likely to be detrimental to the interests of the shareholders until such time as the matter shall have been brought before the general meeting. The last-named member of the board is responsible to the whole extent of his property for anything done at the board meetings to injure the bondholders' interests.

61. *The Chairman.*—The directors choose a chairman and a deputy chairman from their own number. The chairman fixes the date of the meetings of the directors, leads their discussions, and sees to the fulfillment of their resolutions. The chairman carries on the management in accordance with the by-laws. He controls the accounts and the correspondence and sees to the general interests of the company. One of his special duties is to go through the accounts at least once a month with another director and the bookkeeper and to enter the results of his investigations in the minutes of the next directors' meeting. As compensation for his trouble the chairman draws from the management fund an annual salary of ——— pounds.

62. *The Company's Attorney.*—The directors will choose a solicitor, resident in Copenhagen, as their adviser. He will see to all legal matters, examine all documents issued to see if they are made out in legal form, and conduct any correspondence about them. Finally, he will keep the minutes at the directors' meeting and at general meetings. The attorney has only the advisory function at directors' meetings. His annual salary from the management fund will be ——— pounds.

63. *The Duties of the Directors.*—The directors manage the affairs of the mortgage bank in accordance with its by-laws and the resolutions passed at general meetings. They represent the company as regards its rights and privileges in its relations to its own members, to it bondholders, and to everyone else who has business dealings with it. Their undertakings are legally binding upon the company without requiring any special conformation. Every member is, on the other hand, entitled to ask for information with regard to the directors' proceedings and to make comments upon them, which comments the directors are bound to consider. The directors settle all current expenses of management. They represent the company in the law courts and can make agreements in its name. Finally, they can engage all persons needed for the carrying out of its business, with the right of either party to give notice to the other.

64. *The Cashier and Bookkeeper.*—The cashier and bookkeeper do all the cash and bookkeeping business in accordance with the instructions and the directions given to them by the chairman and the directors. The cashier draws from the management fund a yearly salary of ——— pounds; the bookkeeper one of ——— pounds.

65. *The Accountant.*—The accountant has to examine the accounts and to make a preliminary investigation of the requests for loans. About the latter he must send in a written report, besides undertaking all the accountant's business which may be entrusted to him. His yearly allowance from the management fund will be ——— pounds.

66. *The Balance Sheet.*—The directors must see that the books are closed on December 31 every year and a complete statement of accounts made out from them, showing not only the company's assets and liabilities, but also its real financial position and the results of each year's management. The balance sheet is examined by the accountant, who reports upon it to the directors and brings before them any objections to it, which he may wish to have considered. After

the directors have passed the balance sheet it is handed over to the committee of revision (par. 67) on June 30 at the latest. When they have examined it, the balance sheet, together with a statement of the assets and liabilities of the company as certified by the royal commissioner, is published. At the same time the detailed statement of accounts is kept at the company's office and is at the disposal of any member who may wish to examine it. The directors must give every year to the general meeting a report of the management of the company during the past year; also, they must at the end of each half year produce for the reassurance of the bondholders the acknowledgment from the chancery to the effect that it has been informed by the directors as to the state of the sinking fund account, which has been kept in accordance with the rules of double-entry bookkeeping. They must also produce a receipt showing that the amount of the said fund in bonds which have been redeemed has been deposited in accordance with the requirements of the law.

67. *The Committee of Revision.*—Every five years three members of the company are chosen by the general meeting to be members of the committee of revision. They take no part in the management of the company. Their sole duty is to examine the accounts in the name of the general meeting after they have been passed by the accountant and to assure themselves that the banking department is properly managed. The committee reports the result of its investigations to the general meeting, for which reason the accounts must be submitted to it by the directors a month before the general meeting takes place. The directors are also bound to supply the members of the committee with whatever information they may require. The committee of revision may request the calling of an extraordinary general meeting:

(1) When the accounts are not submitted to them at the proper time.

(2) When they discover mistakes in it which are not satisfactorily explained.

(3) When they think that extraordinary precautions, such as the directors are incompetent to take, ought to be adopted in order to prevent serious disasters.

68. *The Royal Commissioner.*—The duties of the royal commissioner nominated by the Government are to be present at the meetings of the directors, or to keep himself informed as to what has taken place there, to inform himself as to the management of the company, and to memorialize the directors as to any of their proceedings

which may be contrary to their own by-laws or to the laws of the land. Should his warnings be disregarded, he must report the matter to the royal Danish chancery, to which the company, as a public institution, is subject.

# MODERN EDUCATIONAL MOVEMENTS

During the past fifty years both the ideals and methods of education have undergone a radical change, the beneficial results of which promise to be so great that they can scarcely be forecast. This change has affected not only the universities and colleges but the high and graded schools as well, so that its influence touches every phase of our school system. The "University Extension" movement was begun in response to a popular demand for instruction on many of the subjects taught only in the college and university class rooms. Its avowed object was to make known to a wider public the results obtained in laboratory and other research work, to reveal the ideals that had dominated the class room, to awaken a wider interest in education, and to bring the teachers into living contact with the busy men and women of the world. An account of this work is given by Dr. Charles R. Van Hise, President of the University of Wisconsin, which is acknowledged as one of the leading institutions in the extension movement.

The trend of the movement in the public schools has been toward vocational training and many systems have been brought forward and developed with varying degrees of success. The object of this phase of the movement is not to discard, or break away from the established academic course, but to furnish the child with training in the fundamentals of some trade, toward which the talents or inclinations of the child lie, so that it may enter the business world with some practical knowledge to depend upon. Among the systems, which stand out prominently and which have successfully applied, are, the Gary System, inaugurated by William Wirt of Gary, Ind., and the Cincinnati, Ohio, Cooperative System developed under the direction of Dr. Herman Schneider. The following articles by Mr. Wirt and Mr. Wulfing and Dr. Schneider show the theory and application of these systems.

## UNIVERSITY EXTENSION IN THE UNITED STATES

*By Charles R. Van Hise*

THE idea of culture was, and to a large measure is, the central ideal of the colleges of liberal arts whether a part of a University or an independent college. The idea of vocation was introduced into the higher educational institutions when the demand for technical education arose; it is represented in the universities by colleges of agriculture, engineering, schools of chemistry, commerce, journalism, etc. The idea of research came into the American university in a large way when Johns Hopkins was founded; it is now regarded in the greater universities as of correlative importance with that of culture. In a broad sense the idea of culture, the idea of vocation, and the idea of research are held and developed in order that an institution may perform service; and thus the idea of service may be said to be the ultimate purpose of the ideas of culture, vocation, and research. The service here under special consideration is that which goes directly to the people of the state and nation which is known as University Extension.[1]

### *General Principles Involved*

The principles which demand such service may be clearly formulated. To about the middle of the 19th century the advancement of knowledge was comparatively slow and at least a fair proportion of the knowledge that the people could apply had been assimilated by them in the more enlightened nations. But since the year 1850 the advancement of knowledge has been greater than in a thousand and probably in five thousand years before. The result is that the accumulation of knowledge has far outrun the assimilation of the people. Much of this knowledge has accumulated during the past twenty-five years, since men still in full maturity have left the schools and colleges.

To illustrate: We know enough so that, if that knowledge were applied, the agricultural product of the nation could be easily doubled. We know enough about soils so that they could give this result and improve in their fertility instead of deteriorate. We know enough

[1] The statistics contained in this article have been in large measure taken from the bulletin by Louis E. Reber upon University Extension in the United States, published by the United States Bureau of Education, Bulletin 592. Also other information is taken from this bulletin.

DOMESTIC SCIENCE AT EMERSON SCHOOL, GARY, IND.

about scientific medicine so that if the knowledge were applied, infectious and contagious diseases could be practically eliminated within a score of years. We know enough about the breeding of animals so that, if that knowledge were applied to man, the feeble minded would disappear in a generation, and the insane and criminal class be reduced to a small fraction of their present numbers. Even in politics we have sufficient scientific knowledge so that, if it were fully used, there would be a vast improvement in the government of this country.

The specific idea of service under consideration is, then, that the university shall carry to the people the knowledge which they can assimilate for their betterment along all lines.

It may be suggested at this point that, while this idea of service cannot be gainsaid, it is not a function of the university but rather of some other instrumentality. If it is meant by this that it has not been the function of the traditional university, to this dissent cannot be made. But it seems to me that whether it is the function of the University should be decided by the simple criterion as to whether the university is the best fitted instrument to do this work. If it is, it should do the work without reference to any person's preconceptions as to the scope of a university.

By the phrase "carrying out knowledge to the people," I do not mean to include the regular instruction of the elementary, secondary, and vocational schools to children of school age, nor the instruction in colleges and universities. To those having the opportunity of elementary, secondary schools, colleges, universities, and professional schools, the best means of transmitting knowledge is the regularly organized educational institution; but, as has already been indicated, a large part of the knowledge which could be applied to the advantage of the people has accumulated since the men and women of middle age have left the schools; and also large numbers of men and women, now engaged in the active work of the world, have not had the opportunities of the schools. It is this great class of people, constituting roughly about four-fifths of the population that is now being considered.

Carrying out knowledge to the people requires the highest grade of experts. It involves comprehensive knowledge of the more recent advances along all lines. The work of carrying knowledge must be organized at some center. What other organization can meet these specifications better than a university? Objection has been made to this undertaking by the university on the ground that it will involve

work which is not of college grade; a further objection has been made, that, so far as the work is of university grade, it cannot be done elsewhere as well as at the central institution. The hypothesis upon which the first objection is based is that the university shall not extend its work beyond traditional boundaries. The second objection is a theoretical one which must be weighed by results; and, even if the objection be sound with respect to some subjects, it does not follow that this is true for all.

If a university is to have as its ideal, service on the broadest basis, it cannot escape taking on the function of carrying knowledge to the people. This is but another phraseology for university extension, if this be defined as extension of knowledge to the masses rather than extension of the scope of the university along traditional lines. The history of university extension shows that the point of view above given was appreciated in a measure by the Oxford Commission which drew up a scheme for extension in 1850, more than sixty years ago.

I therefore conclude that the broadest ideal of service demands that the university, as the best fitted instrument, shall take up the problem of carrying out knowledge to the people, so far as the same is necessary to supplement the work of the elementary and secondary schools.

By the above it is not meant to imply that the university is the only instrument which can perform extension service. Work of this class has been done for many years by the Lowell Institute in Boston, the Cooper Institute in New York, the Peabody Institute in Baltimore, and by other less noted institutions. These institutions have special foundations, the money of which was largely granted for what now may be called extension work; they are conclusive evidence that the founders had a clear appreciation of the needs of the people for the extension of knowledge. Other important instrumentalities for extension are the various lyceum bureaus, Chautauquas and their summer schools, literary and scientific circles, and the various schools of correspondence.

With a few notable exceptions, however, it is clear that the university is the institution which is most advantageously organized to carry on extension work. A few years ago it might have been a moot question as to the advisability of recognizing as a function of the university, in addition to those of instruction and investigation, this third great field. But now the consensus of judgment of men in charge of universities has clearly decided the question. As has already been indicated, the idea originated at Oxford; Cambridge followed Oxford's lead.

So far as I am aware university extension was first definitely organized in this country by the University of Wisconsin. In that institution Agricultural extension in the form of farmer's institutes had an annual appropriation of $12,000 as early as 1885; but it was not until 1888-89 that the English idea of university extension was there taken up. Says the catalog of 1888-89 (p. 51): "The realms of knowledge widen as fast as the possibilities of instruction, and faster than the possibilities of general reception; but it is no more impracticable to extend the popular range of university education than to extend the sweep of the university courses. It can scarcely be more prophetic to contemplate the higher education of the masses today than it was to look forward to the common education of the masses a few centuries ago. The latter nears its realization; endeavor now begins to reach forward toward the former."

While not signed, unquestionably these are the words of Dr. T. C. Chamberlin, then president of Wisconsin.

The English extension idea soon spread and was taken up not only by other universities but by many organizations and societies; some of the latter being definitely organized for this work. For instance, extension work began at Minnesota in 1890-91, only two years later than at Wisconsin, the work being done at St. Paul under the auspices of the Academy of Science, and in Minneapolis under the direction of the Public Library Board. The earliest and perhaps the most successful of the independent societies was the American Society for the Extension of University Teaching organized at Philadelphia in 1890.

The idea of extension caught like wildfire; by the end of 1890 it is reported that more than two hundred organizations were carrying on extension in nearly every state of the union; and a national conference on university extension was held in December, 1891, at Philadelphia.[2]

The extension movement, taken up with great enthusiasm, had an immediate success; but, like many others a propaganda, its activity and strength were largely ephemeral. In a few years, with the exception of Agricultural extension, there was a distinct decline in the power of the movement, and many institutions which still announced extension did this work only to a very small amount in a nominal way.

[2] Proceedings of the First Annual Meeting of the National Conference on University Extension, pp. 201, 202, 203, 209, J. B. Lippincott Company, 1892.

One marked exception to this is the University of Chicago. Its first annual register announced a comprehensive university extension division which included a lecture study department, a class work department, a correspondence teaching department, an examination department, a library department, and a training department.[8]

The extension division, as thus organized, was pushed vigorously for a number of years; but one department after another was dropped until at the present time the only department continued is that of correspondence. This department is a strong one. Instruction is given in a considerable number of subjects and the number of students is large.

Wisconsin was among the universities in which the extension movement, pushed with enthusiasm for a few years, later waned in its influence. It was not until the year 1906-7 that the extension division, then moribund, was reorganized on a new basis. Since that time a large number of state universities have again taken up extension work vigorously and the movement has greatly expanded in the endowed institutions.

In 1914 thirty-two state universities reported themselves as having extension divisions, and almost without exception, the twenty-five or more independent agricultural and mechanical colleges are doing extension work. The list of state universities having extension work is as follows: Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Michigan, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Tennessee, Texas, Utah, Washington, West Virginia, Wisconsin, Wyoming.

Columbia and Harvard well illustrate the recent expansion of extension work in the endowed universities. In Columbia until the year 1910-11 extension was carried on under the trustees of Teachers College; but, beginning with that year, the university took full control of and financial responsibility for extension teaching, a director being placed in charge of the work. President Butler says it is the purpose to extend the class room and laboratory work in the evening in New York City and in the neighboring parts of New Jersey, New York, and Connecticut; and, in addition, evening classes will be organized which may be taken advantage of by wage workers.

In 1913 the lecture work at Columbia University was organized

[8] Annual Register, University of Chicago, 1892-93, pp. 173-198; Ibid., 1913-14, pp. 454-472.

into an Institute of Arts and Sciences. Under the auspices of this Institute, it is expected to give a large number of public and general lectures which are avowedly popular and are intended to stimulate and instruct. Thru this institute it is expected to place the resources of the scholarship of the university at the service of the population desiring information concerning varied fields of intellectual endeavor.

President Lowell's report[5] for 1909-10, tells of the creation of a permanent commission on extension courses, containing representatives of Harvard and Boston universities; the Massachusetts Institute of Technology; Boston, Tufts, Wellesley, and Simmons Colleges; and the Museum of Fine Arts. The commission arranges that numerous instructors give courses which are identical with or equivalent to those offered in the several institutions. The courses are maintained in part by fees from the students and part from subscriptions from the Boston Chamber of Commerce and the Lowell Institute. The administration of the extension work has been undertaken by Harvard; and to this end an administrative board for extension work was created with a dean for its chairman. For students taking work by extension, a special degree has been instituted by Harvard, Radcliffe, Tufts, and Wellesley, —that of associate in arts which without any requirements for entrance is to be conferred upon those taking courses equal in number and character to those required for the degree of bachelor of arts. In 1912-13, two of these degrees were granted for the first time. It is interesting to note that this degree of associate in arts will suffice for admission to the graduate school of Harvard University and other institutions. Chicago has already been mentioned. Other endowed institutions are carrying on more or less extension work. Among these are Brown University, Tulane, Pittsburg, and Northwestern.

The rejuvenated movement for university extension, beginning about eight years ago, has shown power and breadth. The new movement, guided by the experience and disappointments of previous years, is upon a sounder and broader basis than heretofore. Indeed, it may be said, that the policy of carrying out knowledge to the people has become a general one with the majority of the stronger American educational institutions; and it may be confidently predicted that those universities that have not already recognized this policy will do so in the near future.

I shall therefore give a brief outline of the several lines of exten-

[5] Report of the President and Treasurer of Harvard College, 1909-10, pp. 20-22.

sion endeavor in this country, without any attempt to make the same exhaustive, concerning the particular lines of work done by the different institutions. So far as specific institutions are referred to, this will be merely for the purpose of illustration.

*The Lyceum Method of Extension*

The extension method of Oxford was that of a set of lectures with colloquiums and examinations. Naturally this was the first method of extension transported to this country. As already noted, the method was enthusiastically accepted by many universities, but few have persisted in continuing it on a large scale.

The chief illustrations are the University of Wisconsin and Columbia University [6] in the city of New York. Much has been accomplished by the method, but its limitations have clearly appeared. The difficulties of a sparsely settled country have prevented its wide application, and in those institutions which are located in a great city, with a surrounding dense population, the movement has been most useful. Another difficulty with the lecture system in the past is that it has been self supporting. In order to accomplish this, it has been necessary to have classes of large size; it has been necessary to make the treatment of a subject popular; and it has been necessary in the same community to follow one popular series of lectures by another of a wholly different kind.

While I would not underestimate the importance of the influence of extension lectures and the inspiration aroused by them, the method has the fundamental defect that it consists mainly in pouring in knowledge upon the recipients rather than consistent instruction for some length of time along definite lines,—involving not only pouring in but drawing out, not merely giving information but requiring students to do work. In short the lecture system is informational rather than educational.

The above facts have led to this class of work being dubbed "second rate at second hand." The above reasons explain why, after extension was first taken up in this country, the Lyceum method of university extension to a considerable extent had a flash in the pan existence.

Various universities continued lecture work for a number of years, among which Chicago was perhaps the most successful; but even

[6] Annual Report of President Butler, 1912-13, Columbia University, p. 48.

this institution finally abandoned this field of work. However, with the rejuvenation of extension work, this field has again been taken up; and at the present time a considerable number of institutions are supporting the Lyceum method of extension on more varied plans than the formal courses of lectures which were first offered in accordance with the Oxford system. Many of these lectures are frankly informational in regard to subjects of interest. Any subject may be treated in one or more lectures. Little study is expected from the audience in most cases, but the information furnished is useful, or inspirational, or both.

*Instruction by Correspondence*

A second phase of extension work is that of instruction by correspondence. In this line the proprietary schools, not the university, first found the opportunity, exactly as education in medicine and law were not first developed in connection with the university but in the proprietary school. The great service which the proprietary correspondence school has performed to education in this country cannot be gainsaid. Hundreds of thousands, indeed, it is claimed, millions of students have received valuable instruction through this medium. While many universities have announced correspondence courses, for many years Chicago maintained primacy in successful correspondence work on a large scale; and to the present time, this institution has a large number of students. The number of registrations increased from 1,485 in 1901-2 to 4,479 in 1912-13; and in the latter year the actual number of different students was 3,182. The force of the faculty engaged in carrying on correspondence during the same period increased from 92 to 127.

The Chicago correspondence work includes that required for entrance to the university and courses of college grade, each of which is recognized for its particular purpose when satisfactorily completed and an examination passed.[7]

At Wisconsin the correspondence work differs from that in Chicago in that a large proportion of it is vocational. Out of 7,662 students doing correspondence work in 1913-14, 3,481 were carrying vocational courses not of college grade or designed for entrance to college; and 3,296 were doing work of college grade. This vocational work is very largely with apprentices and artisans, who finding that their vocational training is inadequate (indeed there has been no opportunity to obtain

[7] President's Report, University of Chicago, 1912-13, p. 235.

regular vocational training in this country), desire to gain knowledge of the industry in which they are engaged whether it be pattern making, plumbing, machine work, foundry work, etc., etc.

This is the class of work in which the proprietary correspondence schools have found their great opportunity, although their work is not confined to it.

When vocational correspondence work was developed at Wisconsin defects appeared. The method required an unnatural amount of stamina on the part of the student; many artisans who never came in contact with a teacher would not continue work by themselves in the evening after they had finished a day's work in the shop.

To remedy these defects a group of vocational students in a large shop are organized in groups for the same work, and arrangements are made with those in charge of the manufactory for the traveling professor to meet the men from time to time in class. In most cases the manufacturer is willing to furnish a room for this purpose and gives the men the time necessary for them to meet their instructor without reduction of pay. However, with the development in the state of university extension districts more suitable class rooms have been made available, and meetings are held at more convenient times both for instruction and for study. Though the shop room class still prevails, these class groups now meet more largely in the district office rooms, in public library rooms, school rooms, and other institutions coöperating with the University of Wisconsin. At present Wisconsin is carrying on about 75 classes of this kind. Modifying and supplementing correspondence work by class room work places the institution on a new and higher basis. One result of the improvement is that instead of a very large percentage dropping out before completing a course, as in the case in the proprietary schools, this percentage has become small.

There can be no question that correspondence work, especially if it be correspondence modified and supplemented by class room work, has an enormous advantage over the lyceum method of instruction in that it is truly educational, in that it demands that students do definite and systematic work under the guidance of a teacher.

Both at Chicago and at Wisconsin correspondence work, when satisfactorily done in courses of standard character, is accepted to one half the amount required for a degree; thus the student may do one half of his work for a baccalaureate degree in absentia. Also a certain, but not so definite, an amount of graduate work may be done to count toward a second degree.

Upon a priori grounds, many objections have been brought forward by professors against accepting such work for credit toward a degree; and undoubtedly some subjects can better be treated by correspondence than others. This difficulty is met at Wisconsin by requiring no department to offer correspondence work; but many departments do give such work. It is the testimony of those men in departments that have correspondence courses that they succeed in getting work of at least as high average grade as from an equal number of resident students.

It is my profound conviction that the correspondence method of instruction will become of increasing importance in work of college grade, and that it has a vast opportunity in vocational work at least to such time in the future as continuation and vocational schools are developed in this country on a basis as thorogoing as in some parts of Germany.

### *Regular Classes*

A third line of extension work is that of systematic instruction at other places than the university by regular members of the staff. So far as I know this method is most extensively in vogue in Columbia; but it has also been largely applied in Wisconsin at Milwaukee and other cities, and in Massachusetts to a certain extent at Harvard and other associated institutions.

Undoubtedly this is the most satisfactory form of university extension. Indeed at centers, where there are proper facilities in the form of books, or there are available to the students laboratories, this form of extension work may be made as effectively educational as the regular college or university work at the central institution.

The method of regular classes has limitations. It can be best applied in cities which have library facilities and contain a university in which men are willing to undertake additional instruction work. Thus class room work is especially effective in New York City and Chicago. Where the method is used in cities of smaller size which do not contain a university, and have library facilities, it is necessary for members of the university staff to go to the various localities. This has proved to be practicable in a large way only for those universities which have an independent extension staff. In Wisconsin, the traveling library system of the state adds to the efficiency of this form of extension instruction.

## *General Welfare Work*

All of the above lines of extension work are of a kind for which a fee may be charged, and which therefore can be made to a greater or less extent self-supporting. In many cases these lines of endeavor already mentioned have been made altogether self-supporting, but it cannot be hoped that this will be true in the future. Extension if made truly educational along the highest lines and with the best results, like any other educational work, will inevitably become a source of expense to an institution.

For another class of extension there is no return in fees; it is wholly a source of expense. This may be called general welfare work. In such work every university in the country is engaged in varying degree; and in many of them it is important; but so far as I know this division of extension work is on a more systematic basis at Wisconsin than elsewhere; and, therefore, that institution is used for illustrating the principle.

Some of the functions of the department of general welfare in Wisconsin are as follows: It serves as a clearing house to answer reasonable inquiries of the people from all parts of the state in reference to any question concerning which they desire information and expert advice. As has been indicated, the accumulation of knowledge is so vast and it is stored in so many hundreds of thousands of books and pamphlets that it is wholly impossible for a man in a rural community with small library facilities to get the data needed concerning a subject he is considering.

Information can be very efficiently and economically distributed by an organized central staff having this as a special field. Its scope includes hygiene, sanitation, economics, politics, ethics, sciology, education, conservation,—technical questions in agriculture, engineering, manufacturing, mechanics, etc. A vast amount of work in the general welfare department has been done without differentiation, including the answers of many thousands of questions, conferences upon many matters, and assistance to many individuals and organizations.

*Expert Service to the State.* Certain lines of general welfare work have become so important that they have become definitely formulated into special fields. One of these is service by a staff of university experts for economic, social, engineering, and other technical questions, which arise in the legislature, before the commissions, or in the various state departments and institutions.

For many aspects of state administration and legislation requiring expert advice, the assistance of a university staff may be asked. Help should be granted when asked. Great care should be exercised not to volunteer in these matters, lest the impression should become justified that a university is exercising its influence in fields not belonging within its scope.

The University of Wisconsin is generally recognized as an institution in which expert service to the state has been freely rendered.

In Wisconsin also a very important technical service performed by the university staff is that of service upon state commissions without compensation from the state. These include the live stock sanitary board, the geological and natural history commission, the board of agriculture, the forestry commission, the board of immigration, the free library commission, the conservation commission, the board of industrial education, etc.

Columbia has a legislative drafting department. Some states have legislative reference departments which ask the coöperation of their universities to a greater or less extent. Here are included California, Illinois, Nebraska, and Wisconsin. In a number of universities there is coöperation in municipal work. These are illustrated by Johns Hopkins and Chicago. Indeed the municipal research and reference departments in many states are calling upon professors in the universities for expert service.

*Municipal Reference Bureau.* Colorado, Harvard, Indiana, Kansas, Minnesota, Washington, and Wisconsin have municipal reference departments. The work of such a department is well illustrated by the University of Wisconsin municipal bureau. This bureau furnishes information concerning many subjects of municipal organization and administration, including public utilities, paving, sewage disposal, water supply, and the hundred other problems having scientific aspects which arise in a city. In Wisconsin, when first established, there was some fear that this bureau might create criticism as entering into questions having a political bearing; but the information furnished by the university concerning the various problems was strictly scientific; and no criticism has been occasioned.

## *Debating and Public Discussion*

Another class of general welfare work which has been regularly organized is that of debating and public discussion. The American

youth everywhere wishes to debate. At the cross roads and in the country town are very scanty libraries, or none at all; and they are unable to decide wisely upon questions for discussion. As a result of the establishment of this department various political and social questions before the people have been formulated as subjects for debate. Syllabi have been prepared which give in outline the legitimate arguments on both sides of each question, with references. Since the rural community has not the documents referred to these are sent with the question: they are available to the debaters of both sides. The most burning political questions of the day have been analyzed and sent out to all parts of the state, such as the primary election, the election of senators by popular vote, the commission form of city government, the guaranty of bank deposits, etc.; and, yet, so fairly have the two sides of each question been presented in the syllabi that there have been no complaints regarding this department.

*Educational Exhibits.* Another class of general welfare work in Wisconsin is that of educational exhibits of various kinds which are made at the county fairs, the state fairs, and the villages and cities. This class of exhibits may be illustrated by the tuberculosis exhibit which has been shown in those towns of the state, many in number, which would furnish quarters for the exhibit, without cost to the community except that of transportation.

*Institute and Convention.* Another line of work which has been undertaken in Wisconsin is that of institutes and conventions. Some are of a vocational nature lasting a few days, such as, the bakers' institutes. Others broadly concern society and educational questions, as in the case of the municipal and social institute held in Milwaukee in 1910-11, which extended thru six months.

The community institutes have proven very successful. These, according to Dean L. E. Reber, "are three or four day meetings at high pressure to bring to a focus the community consciousness upon its most pressing problems. The endeavor is to fit the program for this institute to two or three of the most pressing problems of a community, and produce such a vivid impression that permanent results may be seen in the community itself taking up active measures for the solution of its problems under the inspiration and suggestion of experts furnished by the extension division." [8]

The convention is well illustrated by the National Conference of

[8] University Extension in the United States, L. E. Reber, Bulletin 592, U. S. Bureau of Education, Washington, D. C., p. 53.

MACHINE SHOP IN EMERSON SCHOOL, GARY, IND.

Boy in Foreground is Planing Chase for use in the Print Shop

Civic and Social Center Development, held in October, 1911, at Madison.

*In General.* The above sketch of the welfare work at Wisconsin is used as an illustrative case because these developed further than in any other state. It is clear that there is no limit to the amount of that class of extension work which may be advantageously done. It is, however, a work which cannot be made self sustaining. The funds have come mainly from the extension appropriation, altho in some cases, as in that of the municipal and social institute at Milwaukee, special gifts were received. The Anti-Tuberculosis association has contributed to the expense of the tuberculosis exhibit from the sales of the red cross seals.

## *Agricultural Extension*

The foregoing statement as to the scope of University extension has not included agricultural extension which is a class of work by itself, having manifold phases, and which to treat adequately would occupy much additional space. Suffice to say, that it has not been found adequate to make agricultural discoveries at the various scientific agricultural stations of the other countries at Washington, and the various stations of the several states of the Union. These discoveries may be embodied and expounded in bulletins and distributed broadcast without producing a widespread effect. It is necessary to go out, and figuratively to knock the farmer over the head with agricultural knowledge in order to get him to apply it. Consequently there has been organized by the United States government and by the various state experiment stations and agricultural colleges, agricultural extension on a vast scale, including farmers' institutes, farmers' schools, short courses for farmers at the university and colleges, demonstrations in the field of various kinds, demonstrations farms, dissemination of high bred seeds thru organizations such as agricultural experiment associations comprising the graduates of the institution, boys' clubs leading to contests in county fairs, dairy scoring exhibitions, extension lectures, etc.

With reference to the future there can be no question as to the prime importance of the agricultural extension work. Already in this country, a comparatively new one, a large proportion of the land east of the Allegheneys and Blue Ridge and a considerable portion of it even so far west as the Mississippi River, has become more or less depleted in richness, and large areas have been partially or wholly destroyed.

In the years to come, there must be food and clothing from our soil for hundreds of millions of people instead of a hundred million, and within two or three centuries perhaps five hundred million people. If this vast host is not to be severely circumscribed in their development, as are the people in India and China by insufficient food, this can only be accomplished by the dissemination of agricultural science to many millions of farmers of the country, a truly colossal task; and yet one which must be vigorously and successfully confronted.

### *General Statements*

It is apparent from the foregoing summary that the work of carrying out knowledge to the people is one of enormous magnitude and not inferior in importance or in opportunity to the functions of the university earlier recognized,—those of instruction and research. The work is so vast that it can be best organized with the states as centers. In those states in which the universities are mainly endowed institutions these may well coöperate with one another, as is now proposed in Massachusetts. In those states in which the universities are tax-supported institutions they are the natural centers of organization. When fully developed, the work will not only involve in each state a center at the university but district centers. Already in Wisconsin six such district centers in addition to the center at Madison are established.

It should be realized at the outset that effectively carrying out knowledge to the people will prove to be expensive. For the work definite funds must be available, precisely as for the other colleges and divisions of a university. We may confidently predict that extension work will be sympathized with by state legislatures and will be one for which an appeal may be successfully made. To illustrate, at Wisconsin in 1905, enough of a start was made in extension from appropriations made to the general university fund so that by the year 1907 the legislature was asked for $20,000 a year for this work for two years. This sum was granted. Two years later, in 1909, there were appropriated for general university extension $50,000 for the first year and $75,000 for the second year of the biennium; and also $30,000 a year for two years for agricultural extension in addition to $20,000 per annum for farmers' institutes.

In 1913, the legislature increased the appropriation for general extension to $177,380 for 1913-14, and $206,110 for 1914-15; the fees however to go into the state treasury. The net effect of this appropria-

tion was to increase the appropriation by an annual increment of $25,-000, or to make the state's contribution $150,000 for 1913-14 and $175,000 for 1914-15. The agricultural extension appropriation of $40,000 a year for two years was continued in addition to the appropriation of $20,000 a year for agricultural institutes. Thus there was available for extension work of all kinds in Wisconsin for 1913-14, $237,380 and for the year 1914-15, $266,110.

It should be remarked that these increases in appropriations for extension have not resulted in curtailing the appropriations for the other divisions of the university.

Aside from Wisconsin, excluding agricultural extension, the following institutions in 1913-14 had appropriations for extension as follows:

| | |
|---|---|
| University of Arizona | 2,200 |
| University of California | 10,000 |
| University of Colorado | 3,000 |
| Columbia University | 104,000 |
| University of Florida | 11,500 |
| Harvard University (from the Lowell Institute) | ⅔ of expenses |
| Indiana University | 4,200 |
| State University of Iowa | 15,000 |
| University of Kansas | 15,500 |
| University of Maine | 25,000 |
| Miami University | 1,000 |
| University of Michigan | 10,000 |
| University of Minnesota | 40,000 |
| University of Missouri | 25,000 |
| University of Montana | 10,000 |
| University of New Mexico | 1,000 |
| University of North Carolina | 1,500 |
| University of North Dakota | 7,705 |
| Ohio University | 6,000 |
| University of Oklahoma | 7,500 |
| University of Oregon | 15,000 |
| University of Texas | 39,407 |
| University of Washington | 12,500 |
| University of Wyoming | 1,000 |

These appropriations are annual unless otherwise specified. To

these amounts should be added the fees which come from the extension work.

As already indicated, nearly all of the agricultural colleges are doing extension work, either with specific appropriations or from their general funds; amounts devoted to such work varying from $60,000-$85,000 per annum, as in the case of Wisconsin and Cornell respectively; to comparatively small sums.

The extension movement in agriculture and home economics has recently been placed upon a permanent foundation for all the states of the country thru the enactment of the Smith-Lever bill. This bill, passed in 1914, makes an appropriation for each state of $10,000 per annum. The total amount of money for the first year, $480,000, is to be increased by $300,000 per annum until the additional annual appropriation is $3,000,000. This additional amount is to be divided among the states in proportion to the rural population, with the provision that no state may gain any of this money without appropriating an equal amount. The monies are to be spent for "instruction and practical demonstrations in agriculture and home economics," and the "imparting of information on said subjects through field demonstrations, publications, and otherwise." That this act will have a profound and far reaching effect in agriculture and home economics extension work cannot be doubted. It is certain that all the states of the Union will participate in the benefits of the bill. If they also make their contribution they may participate largely. It would appear that if the states make sufficient appropriations to take full advantage of the national grants, agriculture and home economics will be adequately, indeed liberally provided for.

### *Conclusion*

The facts presented make it clear that utilizing the opportunity to carry out knowledge to the people will be an advantage rather than a disadvantage to the growth of a university along other lines. But this should not be its purpose; the purpose should be simply that of service. This idea was fully clarified in my mind when Ward's Applied Sociology appeared. Ward there proved that the greatest loss which we as a nation suffer is loss of talent. Talent is not the heritage of the rich, but is equally the heritage of the poor. If we could develop to the highest extent all of our talent so that it would give us the greatest efficiency, not simply along material lines but along all lines, our progress would be amazing. As I have said before, this scientific

treatise of Mr. Ward simply proves what the insight of the poet Gray saw one hundred fifty years ago, that in the country church yard may lie a "mute inglorious Milton." It should be the aim of university extension to make this impossible, to find the way for the boy and girl of talent, whatever the place of birth, whether the tenement on the east side of New York or the mansion on Fifth Avenue, so that the states and the nation may have the advantage of his highest efficiency and at the same time make possible for him the fullest and largest life.

It should also be the aim of extension to assist the ordinary individual as well as the man of talent. If society were perfectly organized, each individual would have an opportunity to develop to the fullest degree the endowments given him by nature whether they be large or small. Doubtless this will never be accomplished fully, but it should be the aim of extension to assist every individual in this direction. This then is the purpose of university extension,—to carry light and opportunity to every human being in all parts of the nation; this is the only adequate ideal of service for the university.

## THE GARY SYSTEM OF VOCATIONAL TRAINING

Public school ideals have changed during the past ten years. This change has been sudden and in a sense surprising. For a long time the doctrine has been preached that the school should train the heart and the hand as well as the head, that the school should develop social and industrial efficiency as well as scholarship, that the school should teach the art of right living as well as arithmetic, reading and writing. But when the public has at last been converted and demands that the whole child be sent to school and that the needs of all the children be met, the school is overwhelmed with its responsibility. Also the traditional school organization and equipment are found to be inadequate.

Until the public accepted the new ideals the school could not command the resources necessary to develop an organization for the new work. The development of an organization requires time. The new ideals of the school cannot be completely realized by a rule of a board

authorizing it to be done. Neither can the methods used successfully in one city be transplanted by fiat into another. Each city must develop within itself a school organization capable of meeting successfully its own responsibilities just as an organization must be created for the successful conduct of any business. It is manifestly unfair to condemn the schools for not having done in the past what they were not expected to do and would not have been permitted to do. You might as well censure the schools for not building your great aqueduct as to censure them for not giving your children a vocational training. The schools have been expected to teach reading, writing and arithmetic out of books and with children strapped in straitjackets to fixed seats. If a teacher attempted to use clay modeling for developing concretely a knowledge of geographic land forms, she was accused of wasting valuable school time making mud pies, or of introducing fads into the school.

The public believed that the school hours should be used exclusively for formal text-book teaching. The making of mud pies was approved for the child's play at home, but valuable time should not be so wasted. In both of these contentions the public was right. But the public was wrong in assuming that the children could be educated in school seats five hours a day working with books for one hundred and ninety days regardless of what they might be doing the other nineteen hours of the school days and the other one hundred and seventy-five days of the year.

The teacher was right in her contention that the children must have real life experiences to supplement the book study and that the child must have a chance to use the knowledge gained from books not only to master the knowledge but also to understand why he should study the books. The first business of the school is to get the child into a condition to be taught what the school has to teach; the child must have good health, intelligence, reliability and industry in order to succeed either in the school or out of the school. The traditional school with children strapped to fixed school seats for nine hundred hours a year and loafing in the streets three hours for one spent in school, is not prepared to develop good health, intelligence, industry or reliability. The teacher knew that she was failing with large numbers of children in the teaching of reading, writing and arithmetic and in developing social and industrial efficiency. But she was wrong in thinking that she could give sufficient opportunity for self activity and concrete experience and also do the necessary formal teaching in the

nine hundred hours school time during the year regardless of the wasted street life of the child.

The public and the teachers now see that the tremendous current of energy expended for the education of the city child is being short circuited through the wasted life of the city street. As long as our city thought was dominated by men and women reared in the country we could not understand the needs of the city child. The principal reason for the great change in the ideals of the school today is due to the fact that our city thought is now being dominated by men and women who were themselves city boys and girls and understand their needs and their handicaps. They know that the average city home cannot provide a sufficient quantity of wholesome activity at work and play any more than it can provide adequate opportunities for study and academic instruction. They desire a public institution that will be a study, work and play school. They want the school to continue to develop culture and scholarship. They believe that when the wasted time of the street is used for wholesome work and play, supplementing the study hours, the school will be more successful in developing culture and scholarship and also be able to fit boys and girls for life. School authorities deserve censure only if they are not now busy developing an organization to get the thing done.

The solution of the problem of successfully educating the city child for life is to be found in utilizing the wasted time of the child in the streets, the wasted time of the classrooms, the playground, the auditorium, the library, etc. The only principle involved in thus turning waste into profit is the utilization of all educational facilities, all of the time for all of the people.

Well-equipped workshops, supervised playgrounds, fine auditoriums and swimming pools are not extravagant luxuries. These additions to the school plant reduce the total cost of the school to the taxpayers. Schools with abundant provision for work and play activities as well as study are extravagant only in the opportunities offered the children.

Pre-vocational training has always been one of the aims of the school. Success in a vocation requires a good working knowledge of English, mathematics and science. A knowledge of civics, literature and history is one of the factors determining the conditions under which we pursue our vocations. Pre-vocational training must cover the entire elementary and high school course. Play for young children is just as vital a factor in pre-vocational training as work is for older children. In the normal development of the child that type of pre-

vocational training is best which naturally and gradually transforms the play impulse into a work impulse.

The children cannot play unless they have a place to play and things with which to play. For play we need only play space, play equipment, and a director. For work we need in addition to work rooms and shop equipment, a master workman and real work to do.

The great problem in the successful rearing of children in cities is to find economically enough suitable self-activity in wholesome play and work. By placing the public supervised playground adjacent to the school where the children can use it every day in the year and all the time during the day, a sufficient quantity of wholesome play activities can be provided often by securing a maximum use of our present play facilities. The school, like the old-time industrial home and community, has a great amount of real work that is now being done and must always be done in connection with the equipment and maintenance of its buildings, grounds, laboratories and shops. There is a great variety of this maintenance and equipment work and types can be selected suitable to every stage of child development. Just as the child formerly participated in the real industrial activities of the home, why not let the child participate in the real industrial activities of his school? The school heating plants, the repair and equipment shops, the lunchrooms, the storerooms, the school offices, can all become laboratories for the industrial and commercial education of the children. These business departments of the schools in Gary have been industrial education laboratories during the past seven years, and it has been conclusively demonstrated that the usual current school maintenance and equipment budgets of the average city will provide ample facilities for the industrial and commercial education of the children. The facilities provided are not only varied and adapted to the child's needs, but they are real, the work must be done, the children receive direct benefits for they are working for themselves, they are participating in a real industrial business in an environment similar to that of the old-time industrial home and community.

The school carpenter, painter, plumber, electrician, cabinet maker, sheet-metal worker, machinist, blacksmith, foundry-man, pattern-maker, printer, engineer, potter, nurse, dentist, physician, landscape gardener, architect and draftsman, accountant, storekeeper, office force, lunchroom managers, designers, dressmakers, milliners, etc., all take the places of the fathers and older brothers in the old-time small shops and of the mothers and older sisters in the old-times homes.

TYPICAL GARY SCHOOL BUILDING

Children Taking Care of Shrubbery on School Grounds, Under Supervision of Botany Instructor

When you have provided a plant where the children may live a complete life eight hours a day in work, study and play, it is a simple matter to permit the children in the workships under the direction and with the help of well-trained men and women to assume the responsibility for the equipment and maintenance of the school plant. An industrial and commercial school for every child is thus provided without extra cost to the taxpayers.

The children work with the masters as apprentices, but apprentices and masters are permitted to do only enough work to balance the wages of the masters and the cost of materials and tools. The evils of child labor are thus eliminated and many model industrial shops and desirable positions for superior adult workmen are created.

This is the age of the engineer, of machinery, and of big business. The school business enterprises offer a much better type of industrial and commercial education facilities than were offered in the old-time industrial home and community. There are big business problems, engineering problems, and machinery problems in the school that offer a type of industrial and commercial training adapted to modern industry and business. We need not regret losing the industries of the home and the small shops as factors in industrial education. The training such industries gave was sufficient for their own day but would be inadequate for modern conditions. Modern business and industry are organized on a new basis and must develop a new type of training for the managers and workers. The responsibility for the development of the new type of industrial and commercial training rests with the leaders of modern business and industry. Their business and their industries must become schools for the training of recruits since the burden can never be shifted entirely to the public schools. But the public school can co-operate with business and industry in a much more efficient way than is now the general practice.

Permitting the children to divide their time between the school shops and classrooms involves exactly the same principle as permitting them to work in shops outside of the school part of the time while attending a co-operative school. If the school shops and offices can not bother with the school children, how can the school expect outside industries to bother with them?

The shop teachers earn their salaries and cost of materials, but take the place of manual training teachers. Manual training teachers, however, should be continued for the children who do not care to work in the productive school shops. The head manual training teacher of

each building should be the vocational advisor for the school, should have charge of the employment bureau and the placing of children in the shops. He should also supervise the part-time, improvement and continuation schools. The shopmen should be employees of the building, supply and auditing departments. The work for the shops should be planned by these departments and the value of the productive work should be reported by them. Since the shopmen together with their students can earn the salary of the master workmen and cost of materials in approximately half the working time, ample opportunitiy is afforded for special school exercises in addition to the productive work.

Not only must the wasted street time of the child, the wasted time of the classroom, the library, the auditorium, the shop and the playground be eliminated; but the time and energy of the teacher must be conserved. It is the business of the administration department of the school to develop and keep the teacher in the best condition to teach, the child in the best condition to be taught, and both in the best possible environment for teaching and learning. A successful study, work and play school provides the best environment for learning and teaching, and develops in the child the right attitude of mind toward the school. The child is thus developed and kept in the best condition to learn and be taught. It has been demonstrated that such a school conserves the energy and time of the teacher. When the children want to know what the school has to teach the teacher's work is comparatively light. In fact no teacher can by any expenditure of energy educate the child. Each child must educate himself. All that the teacher can do is to provide the most favorable environment and stimuli for the child to educate himself. When children are busy educating themselves and the teacher is only a wise director of their efforts, the nervous drain of the traditional school disappears.

In Gary the teachers have an eight-hour day. The regular teachers have four hours in the classroom, one hour in the auditorium, one hour in community and application activities, and are expected to give two additional hours either in the school building or in their respective homes for preparation of work, study and general duties in relation to their school activities. The playground and shop teachers spend eight hours in the playground or in the shop.

The teachers take turns in directing the auditorium exercises, but all teachers are present with their classes. Since the shop, play and other special teachers, together with librarians, religious instructors

of the churches, etc., can look after the children outside of the classroom and auditorium; it is possible to give the regular teachers only a five-hour school day, four hours in the classroom and one hour in the auditorium. The extra hour in community activities is so valuable, however, that wherever possible it should be utilized. The community hour gives the opportunity for all sorts of civic work, visits to libraries, museums, industries, etc. This hour makes possible the application of school studies at play and at work, and enables the teacher with the children to do nearly all of the work of the attendance officer, visiting nurses, and assist greatly in the work of the health department.

When the regular teacher knows the home of the children, the neighborhood in which they live, and comes to look upon her charges as individuals and not as classes, she is better able to meet the needs of each separate child as an individual. There is no good reason why a part of the saving to the taxpayer of the turning of school wastes into profits should not go teachers as extra remuneration for greater service. This follow-up work in community and application activities gives the classroom work its proper perspective for both teacher and pupil. In no other way that I know can the rigidity of the traditional school be so easily broken up.

Respectfully submitted,

William Wirt,
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## THE GARY SYSTEM OF VOCATIONAL TRAINING IN THE PUBLIC SCHOOLS

By G. E. Wulfing, Supt. of Industrial Education, Gary, Ind.

In the fall of 1907, Gary was a newly created city and its people were living in shacks and tents, awaiting the completion of their homes. The school work was begun with a small body of teachers, no equip-

ment except three frame country schoolhouses and two rooms in the only completed office building in the city, and pupils, representing all grades, from the first to the twelfth, were on hand. From this, the city has grown, in eight years, to a city of about 40,000 inhabitants and the school enrollment is over 5,000 children in the day schools and an average monthly enrollment of 4,000 adults in the night school, with an average nightly attendance of 750. These pupils are divided among five centers, of which, the Emerson and Froebel buildings, are buildings of the Gary type, constructed to accommodate 2,000 pupils with necessary class rooms, laboratories, shops, gymnasium, swimming pools, auditorium, and are provided with ample playground and park facilities.

Among the problems which presented themselves in the rapid growth of the city and its schools, perhaps the most perplexing was regarding its finances. There was no money to begin with, and although the schools are supported entirely through taxation, the receipts from any year's assessment were not received until more than a year later. The school enrollment was generally doubled each year and had to be financed on the valuation and assessment of the previous year. Perhaps, this constant shortage of funds, coupled with the determination to have complete and efficient schools, contributed largely to the extensive and practical use of the school plant in making, maintaining, and repairing its own equipment. This practical use of the school plant, which serves as laboratory material for its own shop-work instruction, is one of the characteristics of the Gary school organization.

The prescribed state course of instruction is followed carefully and vigorously, but provision is made for the practical minded child and those who get little from books but revel in the development of muscular skill and work. Every legitimate means is employed to find the interest of every child in the community, whether through play, shop-work, science, music, art, or books. Provision is made for the child's interest in nature and nature study, and rooms are equipped with conservatories, aquaria, and cages for animal life. School gardens are provided with year round supervision, animal life on the grounds is encouraged, and special provisions are made to enable the children to care for pets and donations of animal life. The smaller children are given regular periods of both organized and free play during the school day and under the supervision of special teachers. The older children have been led to utilize their spare time for recreation, and

the gymnasiums and athletic fields are available, with the director on hand, every school day until five o'clock, all day Saturday, and Sunday afternoons during favorable weather.

A longer, or fuller, day for the student, without increasing the number of hours for the teachers, is accomplished by a more extensive use of the school plant than is found in the ordinary type of school. Two separate school organizations, in the same building and each with its own teachers, alternate hourly throughout the day in the use of the class rooms, auditorium, play facilities, etc. For convenience we designate one of these as the X school and the other as the Y school. The teachers of the X school report at 8:15 and are on duty until 3:15, the Y teachers from 9:15 to 4:15, and the shop teachers from 8:00 to 5:00, with such rest periods as may be needed. While the X school is using the class room in book study, the Y school is engaged in special activities such as play, auditorium, laboratories, shops, music, church, library, etc. The accompanying chart is intended to illustrate this double use of the school plant.

For chart and notes, see pages 172 and 173.

Instead of maintaining separate school plants for the graded school and for the high school work, the children are housed in the same building and follow a continuous course of instruction, containing twelve grades. This results in closer relation between the grades and the high school, in increased attendance in the high school, in increased opportunities and inspiration for the elementary school children, and a fraternal and helpful attitude of the high school students toward the grade students. The teaching force becomes better acquainted with both grades of work and the teachers of each become more sympathetic with the work of the other.

The Gary schools are generally thought of as strongly vocational but this is only partially correct. While there is no separate trade or vocational, school, vocational training is given a very prominent place in the curriculum. The amount of time given to hand work, shop work, commercial work, and other lines contributing to vocational training varies with the different grades but holds a prominent position in all grades from the first to the tenth, inclusive. In the eleventh and twelfth grades this work is optional.

During the first two years, one hour daily is given to drawing and hand work, such as clay modelling, paper cutting, weaving, etc. This

## CHART ILLUSTRATING DOUBLE USE OF SCHOOL PLANT

X school shown in Roman face type. *Y school shown in italics.*

| Period | Books in the regular class rooms | In special activities, such as; play auditorium, laboratories, shop, music, church, library, etc. |
|---|---|---|
| 8:15 | Whole X school | ⅓ *Y school in shop, laboratory, or music.*<br>⅔ *Y school in other special activities as program may be arranged.* |
| 9:15 | *Whole Y school* | ⅓ X school in shop, laboratory, or music.<br>⅔ X school in other special activities as program may be arranged. |
| 10:15 | Whole X school | ⅓ *Y school in shop, laboratory, or music.*<br>⅔ *Y school in other special activities as program may be arranged.* |
| 11:15 | *Whole Y school* | Whole X school dismissed for lunch. Shops, laboratories, and gymnasiums available for special students, or special program arrangement. |
| 12:15 | Whole X school | *Whole Y school dismissed for lunch. Shops, laboratories, and gymnasiums available for special students, or special program arrangement.* |
| 1:15 | *Whole Y school* | ⅓ X school in shop, laboratory, or music.<br>⅔ X school in other special activities as program may be arranged. |
| 2:15 | Whole X school | ⅓ *Y school in shop, laboratory, or music.*<br>⅔ *Y school in other special activities as program may be arranged.* |
| 3:15 | *Whole Y school* | ⅓ X school in shop, laboratory, or music.<br>⅔ X school in other special activities as program may be arranged. |

4:15 to 5:15, volunteer students in shops, laboratories, gymnasium, or on playground.

Lower grade pupils have one hour periods in shops and laboratories, while upper grade pupils have program arranged for two hour periods.

Lower grade pupils have regular play periods, while upper grades substitute work for play and get their free play periods after 4:15.

Each school has its program of special activities adapted to its own particular needs and conditions.

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work is given in special rooms with trained teachers. The third, fourth, and fifth grades, in the larger school centers, are placed in the various shops, drawing rooms, and science laboratories, as observers and helpers for one hour each day. This is principally as a means of vocational selection guidance, or selection, and they are changed every three months from one line of work to another. The sixth, seventh, and eight grades have one hundred and thirty hours, at the rate of two hours daily, in a definite vocational occupation. This alternates with thirteen weeks, one hundred and thirty hours, of elementary science, and with thirteen weeks of music and expression, so that each class receives thirteen weeks of each of these lines of activity during the year. The ninth and tenth grades are given two hundred hours yearly, generally in two hour daily periods, and in the eleventh and twelfth grades the work is optional.

The ages of pupils in this work vary from ten to eighteen and pupils of different ages are found in all the shops. The pupils are not placed in the shops according to age or grade in the school, but rather according to trade inclinations and the wishes of the parents. In general, however, children from ten to twelve are more apt to be found in the foundry, pottery, shoe repair, sheet metal and blacksmith shops. Those of twelve and thirteen are found in the painting, forge, store room and office, while those from fourteen to sixteen are to be found working in the machine shop, printing, plumbing, electrical work, and pattern shops. Pupils above fourteen will be found in all shops but those under sixteen are not allowed to work where there is danger from high speed machinery.

Regular manual training shop work is carried on, just as in any other school, under the direction of a licensed teacher. But the

shop work, characteristic of the Gary system, is what is known as the "productive shop" work. This is in addition to the ordinary manual training and is called productive shop work because the definite and more specialized vocational work is carried on here, and because these shops are expected to perform enough productive work to meet the expenses of salaries paid and materials used. The pupils have the choice between this special shop work and the regular manual training work, but it is interesting to note, that in the large centers where a large variety of these special shops can be provided, the children invariably select the special work.

Whenever any specific trade is to be taught, a man, who is a master mechanic with teaching ability, is employed from the trade and given real work to do. These men are not employed as licensed teachers but as actual mechanics and are not paid out of the regular tuition funds. The work provided is work which is needed by the school plant, such as repairs, painting, new equipment, etc., which serves as laboratory material. The pupils work in these shops as apprentices to the master mechanic under conditions approximating those in the trade itself. However, if productive work cannot be provided in any trade, which it is desirable to teach, a licensed teacher of the vocation would be employed and would be paid from the regular tuition fund. This is the case in the present commercial, cooking, sewing, mechanical drawing, and manual training departments. If assistants are employed, for these classes, they are on the same basis as the productive shop instructors and are paid from the proceeds of the productive work. The cooking, sewing, and commercial departments each employ an assistant on this basis.

Since the productive shops are self-supporting, the classes need not be large and they usually contain from six to eight pupils. With such small classes the work becomes strictly individual and the pupil is the first consideration of the instructor. Each pupil is advanced from the simpler to the more difficult processes and problems according to his individual ability, irrespective of what the remainder of the class may be doing. It is the duty of the Vocational Director to check up this work regularly and systematically to see that each child is receiving proper attention.

Special shops are provided to teach the various building trades, such as, carpentry, painting, plumbing, sheet metal work, and electrical wiring. These shops take care of the general repair work of the school plant and its equipment, and, wherever possible, build the new

equipment, which thus serves as laboratory material. The carpenter-cabinet maker constructs desks, tables, cup-boards, special desks, etc. The painter and decorator, with his apprentices keeps the school painting in repair and finishes the work turned out by the cabinet shop. The sheet metal man is responsible for the repair and condition of the roofs in general and makes the sheet metal parts for such things as motors, linings for tanks and sand tables, waste and garbage cans, safety devices, etc. Each school plumber, in a like way, with his apprentices, takes care of the school plumbing and contributes his share to the construction of school apparatus and equipment.

The iron working industries are represented by the pattern shop, foundry, machine shop, blacksmith shop, and also, the sheet metal shop. All the shops are conducted under the same plan, of small classes with the pupils serving as apprentices under the master mechanic, and act as manufacturing and repair shops for the school buildings and their equipment. In the foundry, castings are made for grate bars, desk parts, stool bases, or parts of any apparatus under construction. This foundry work is not confined solely to iron castings, the various alloys and non-ferrous metals being also used. The pattern shop constructs, and keeps in repair, all patterns used by the foundry, and does wood turning, such as making ball bats, Indian clubs, stool tops, etc. The forge is equipped with power machines for heavy forging, cutting, punching, etc. Besides the repair work and the construction of equipment, the school horses are shod, the wagons kept in repair, playground apparatus is made, and tools are made for the plumber, machinist, etc. The machine shop is equipped with lathes, shaper, drill presses, and a milling machine. The general repair work furnishes an abundance of valuable shop practice, and the manufacture of vises, small machines, adjustable laboratory stools, special tools, etc., provides problems of the very best kind for training in practical machine shop practice.

In pursuance of the policy of utilizing the school plant and the school administration, as much as possible, for vocational training, the opportunity is found to fulfill the desire of those whose ambition it is to work in a store or to drive a delivery wagon.

Children, with this inclination, are placed in the store and supply rooms of the school where they receive the necessary experience and vocational guidance by doing real store work. The boys assist in purchasing, in checking up bids and quotations and comparing the samples submitted. The goods are classified, priced, charged out to the teach-

ers and janitors on requisitions, wrapped, labelled and arranged for distribution. Deliveries, within the building, are made by the boys and those to the outlying buildings are made by the milk delivery man of the special school farm.

Cooking is made practical by preparing the luncheon for the teachers and students and a course in cafe management is given. The school board employs a regular domestic science teacher and, from the proceeds of the cafe service, a practical cook is employed as assistant. Sewing, millinery, and costume designing are worked into a very valuable and comprehensive course by the employment of a special teacher in domestic arts, with a practical seamstress or milliner as helper. The school needs in sewing are taken care of by this sewing class and real work is done by the members who make garments for themselves and for others who wish to take advantage of the opportunity.

Two shops of special interest to the foreign population of Gary are the shoe repair shop and the pottery shop.

The shoe repair shop was installed, with small equipment and a practical shoe repair man in charge, to help and encourage the children in the repairing of their own shoes. As this work proved to be extremely valuable in hand training it was continued in the regular classes. Those, who furnish their own material, are given help and direction in repairing and making their own shoes. Other opportunities for this training are found in making shoes for others on order and in making gymnasium shoes. The gymnasium shoes are for use in the school gymnasiums and are sold to the children, at a reasonable price.

The pottery is in charge of a practical potter, who is employed to take care of the clay used in the kindergarten, primary grades, and drawing classes. The clay is purchased, at $5 per ton from the clay bank instead of $40 per ton from the school supply houses, and is worked up into proper condition by the potter. He has constructed eight potters wheels and from eight to ten boys work with him in practical uses of clay. Flower pots for botany and nature study, still life studies for drawing, pottery for the school rooms, and many other useful articles are made. There is no thought of definite trade training in this but the hand training, in the manipulation of the wheel, is extremely valuable.

As the schools under this system require a large amount of printed matter, printing shops have been equipped and are in charge of the best practical printers that could be secured. Both boys and girls are enrolled, as apprentices, and the general printing for the school use

PRINT SHOP, GARY, IND., SCHOOLS

serves as their laboratory material. The various vocational shops have their blank forms, bill heads, requisition sheets, etc. Each department publishes occasional bulletins of its work and issues pupil reports on such subjects as: health statistics, disease prevention, ventilation, garbage disposal, fly extermination, etc., science bulletins on local dairies and bakeries, and on candy making and subjects where pure food is the issue. All this is done by the classes so that the round of printing experience is thorough and practical.

The commercial department of each building is in the charge of a competent instructor who has a member of one of his own classes as a paid assistant. Bookkeeping and stenography are taught. The department, with the help of this assistant, does all the cost accounting of the various shops, the purchase and distribution of supplies; timekeeping of the vocational shop men and their apprentices, and other lines of necessary clerical work. This clerical work serves as laboratory material for a preliminary commercial course and the students assist in it to become acquainted with business terms and methods and the handling of various business forms. This is followed by more formal and abstract instruction and by a regular course in accounting. The course in stenography consists of thorough training in shorthand and the touch system of typewriting, and the students are given practical experience by doing some of the stenographic work of the school.

Both free and mechanical drawing are taught from the sixth grade up, through the high school. A definite amount of each is required and beyond that the pupils are allowed to make their own choice. Freehand drawing is usually elected by the girls and is closely related to the sewing, painting, and printing of the school. This drawing room is provided with Arts and Craft equipment to assist in the application of design. Mechanical drawing, elected by the boys, is allied to the shop work of the school and the course is thoroughly practical. Blue print reading is taught early in the grades and it is difficult, for either boys or girls, to leave the Gary schools without being able to use this universal language.

Special provisions are made so that the students will appreciate and understand the relation between the shop work and its related science. The physics instructor of each building is brought into close contact with the practical by assuming certain responsibility for the heating, ventilating, power production and transmission plants of the building. The electrician and engineer are under his supervision and the pupils from his classes are given practical experience by perform-

ing a certain amount of work under these men. He also gives individual instruction to the pupils in their special shop work and in their auditorium periods he gives them general instruction as to the relation of science to modern industry. Likewise, the manual training teacher will have a class in elementary science so that the relation is maintained from both sides. The association of the work in this way results in a reaction which is beneficial to all classes.

The organization of the special shop work is modelled after that of a modern industrial plant. No work is done in any shop except on a shop order, passed upon by the Vocational Director. Through this shop order, the work is placed in the proper shop and all work that lacks educational value is eliminated. When the work is finished, the shop order, bearing the required cost data, is sent to the commercial department for filing and cost accounting.

These shop orders, together with drawings and specifications furnished by the mechanical drawing classes, enable the shops to work together on the various school manufacturing problems. For example, playground apparatus is needed and plans are submitted. A large part of the work belongs to the forge shop and this shop assumes responsibility for the work. Shop requisitions are then made on the foundry for the castings needed and on the machine shop for the finishing work. The foundry, in turn, makes requisition on the pattern shop for the necessary patterns, and, having received them, makes the castings. Thus the shops co-operate until the job has been completed and the machined fittings and various forgings, with the purchased pipe, are ready for installation on some play ground. Here the students contribute what help they can in assembling and erecting the apparatus. The job has furnished many valuable exercises for the various shops and something useful has been made. The accounting then finds that, on a thousand dollars of equipment the cost is less than $300, and that the balance of $700 represents the manufacturer's cost of labor and marketing. Instead of having spent this $700 with the manufacturer, the school has applied it to the actual training of its pupils, and, in short, has financed this work with these savings.

The total cost of equipment for the vocational work represents an outlay of about $23,000. During the year 1913-14, supplies costing $13,500 were used and salaries in these productive shops amounted to $15,345, so that the total cost was $28,845. The manufactured output, based on the current market values, was $27,875 and the net cost for maintaining these departments of the school was consequently $970.

The total number of student hours, on this work, was 71,514 for the year, so that the student hour cost for salaries and materials was $.014.

A system of timekeeping and credits has been designed to increase the interest and application of the pupils in the vocational work. At the beginning of each week, each pupil in these shops is provided with a blank time card for keeping a record of his time spent on duty. At the end of each week the time is computed and the instructor gives the student his mark. This mark is not graded in the ordinary manner but is made on a cash basis of 60 cents per hour for 100% work, or at a less rate per hour for a lower grade of work. These cards are filed by a student timekeeper who makes out a weekly pay sheet for each shop, and issues a check in "school currency" to each pupil. The student holds, or deposits his pay checks in the school bank, and when he has a deposit of $80 he turns in his pass book and receives a nicely printed credit certificate.

The aim of this vocational work is, not only to give the benefits of this valuable training, but also to bring each pupil into contact with the various trades and guide him in his selection. The child is allowed rather free play in his selection, being advised rather than crowded into any line of work. The vocational guidance supervisor, of each building, keeps in close personal touch with each pupil, and knows his parents and home conditions, so that he is in position to give valuable advice. About 20% of the boys, from the sixth grade and up, have decided on something definite to follow, while the remaining 80% take the regular, general program planned for them. The school system recognizes the fact that the child can best learn a trade by actually working in that industry, but the school believes that it should provide as thorough a preliminary, or prevocational, training as possible. The system is so flexible, that, where definite choice has been made, a special program can be arranged for any pupil and he may take extra periods of mechanical drawing, shop, commercial, or other special work. The older students can arrange for special short unit courses, or for more complete specialized courses in any line of work, and some arrange for part time only.

Very effective trade training is done among the adults in the continuation, or night school. Classes are organized for any line of work, for which there is a demand, and sessions are held four nights a week, from 7:00 to 9:00 o'clock. The regular day school equipment is used and many of these students spend their spare time in the day school. As a rule, the day school shop men conduct these even-

ing classes and the experience of this contact with adults actually employed in the industries, is most wholesome for the effective teaching of the children.

The vocational training in the Gary schools is but a part of the broad and liberal plan of making as extensive use of the school plant as possible. It makes the school a community center where all the school is used all the time for all the people, serving them as their needs are made manifest.

## VOCATIONAL (INDUSTRIAL) SCHOOLS

By Dr. Herman Schneider
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### What Kinds of Vocational (Industrial) Schools Are Needed?

#### *(I)—The Object of Industrial Education*

Industrial education has as its object a progressive community advancement through industrial efficiency. Industrial efficiency is determined by three mutually dependent elements—physical health, mental development and manual dexterity.

The health element in industrial education is only slightly within the jurisdiction of the school authorities, and, except in specific instances, is outside the scope of this inquiry. It will be evident, too, that in some occupations hand skill is negligible—for example, in selling. In nearly all trades, however, it is an important factor. Generally speaking, then, we are concerned with the two elements of mental development and manual dexterity.

If industry itself furnished these two elements, there would be no problem of industrial education. What industry furnishes properly and adequately requires no effort on the part of the school. But, if industry emphasizes one element at the expense of another, or utterly neglects both, the school, standing for community advancement, may enter into the situation. Again, if industry in some of its phases requires a certain type of manual work which leads to mental stagnation, the public school's function would not be to initiate nor to increase such manual dexterity; this would not be education. On the contrary, the school's efforts would aim to counteract the dulling effects of the work. It is obvious, then, before any constructive criticism of industrial programs now in operation or suggestions for their betterment can be formulated, that an analysis of the thing we call work, especially with reference to the mental effects of factory work under modern conditions, is necessary.

### *(II)—Work as Related to Progress* [1]

There is an instinct for work, but basically it is the instinct for self-preservation and self-perpetuation. Work is our individual and collective struggle for existence; and, out of the mental and physical exertion of the struggle to feed, clothe, and house us, has evolved our present state of being. The whole complex machine of commerce and industry—factory, farm, railroad, bank, office, government—has been built for production, construction, distribution, and protection. The present machine is the product of slow evolution; and the effort of the centuries to build a machine which will better cope with the problem has been the primary cause of our advance in the various activities of life. Integrity, honesty, discipline, sound health, fair dealing, respect for others' rights—these have come from the courageous assumption of one's burden of work, and the opposites of these are the results of the desire to dodge the burden.

And so we have a natural law of work, the substance of which is this: Work and you will reach a higher mental development; cease work and you will degenerate.

[1] Most of the material on *work* in this section (II) is taken from former papers by the writer as follows: The University and the Day's Work, New York State Teachers' Convention, Dec., 1910; The Public School and the Day's Work, National Child Labor Convention, March, 1911; Community Efficiency, Commencement Address, Fitchburg, Mass., June, 1911; An Analysis of Work, in Lecture Notes on Some Aspects of Shop Practice, by Alex. Humphries, 1912.

The law can be established scientifically if need be, but it is not necessary, for in this case common observation, science, and religion all agree. Each of us knows he will deteriorate physically and mentally if he ceases constructive work, and history shows that this is also true of communities, of nations, and of civilizations. Our proverbs, sacred and secular, affirm it. The cycle of work to wealth, wealth to idleness, idleness to poverty, and poverty to work again, is an evidence of inefficiency following inaction. Mental and physical activity are mutually stimulating; thinking and doing are reciprocal aids.

Mental training and industry have both been most stable when they have been most closely allied; and until comparatively recent years they have been one in fact. Under the old guild and apprentice systems, for example, the workers were trained so well in the commercial field that industrial education was not a special school problem. Work *was* education. To embark upon an apprenticeship was serious business; careful discussion preceded it and ample documentary agreements gave guarantees of execution. Industrial communities were small, and personal acquaintance fostered personal interest. Competition in skillful execution furnished a lively stimulus which led to the enthusiastic use of head and hand coordinately. Generation by generation there was a cumulative mental advancement coupled with a refinement of manual skill in constructive work. In this manner, even long before the days of formal apprenticeship, mankind grew through work.

But there have been two significant changes in the conditions under which work is done.

In the first place, it is only within the past two or three generations that mankind has worked in masses within walls. For centuries mankind did self-directed work, largely in the open air. These were the farmers, the seamen, and the forest rangers. As civilization grew, a constantly increasing minority did self-directed work, individually or in small groups, indoors; these were the artisans in the skilled trades, who met the demands of growing communities. Then came the great change to the factory system through the development of power devices; this dates virtually from the invention of the steam engine.

In the second place, the industrial worker formerly knew a *whole* job, rather than a part of it; he performed a great variety of functions in the completion of his task, instead of endlessly repeating the same operation. The clockmaker made a *whole* clock, working individually, and a necessity of working out every part's relation to every other part gave the worker a mental stimulus, and, therefore, a higher mental de-

velopment. The finished product was all his own; the desire for self-expression, which every man has, found an outlet through his work; and, once having served his thorough apprenticeship, he worked largely by self-direction. Under our present highly organized industrial conditions the making of a clock is subdivided into a large number of operations. Each workman in a clock factory makes piece after piece of the same kind, principally by feeding material into a machine, and why he does it he need not know and usually is not told. We are putting the brains into the machine and into the management office, and making the workman a purely automatic adjunct.

Now we have, broadly speaking, two types of brain centers; the lower centers controlling habits, and the higher active thinking centers. If one's work is purely automatic repetition requiring no initiative, planning, or diversion, the habit centers are developed and the thinking centers have at best a retarded growth.

In this connection it is necessary to differentiate between casually repeated useful habits of daily life which economize time, and constantly repeated automatic motions which constitute one's major work; the argument is fallacious that, because the former are good, so are the latter. The putting on of one's shoes is governed by one's habit centers: when we were learning to put on our shoes the thinking centers were being developed. Dressing, eating, walking, boarding a car, opening a door are time-saving actions of habit repeated at comparatively long intervals, differing widely in their motor forms, and used as incidental instruments to a larger self-directed action. There is a vast difference between using many habits several times a day as means to self-directed ends, and repeating *one* habit all day as an end in itself. The playing of scales on a piano becomes a habit to the skilled musician; he uses it as a means of performing a stimulating, energizing, thought-requiring production. It is a good and beneficial habit which facilitates and simplifies his performance. But if he learned the scales merely to repeat them ten hours a day, day after day, without meaning and without end, his work would become lethargizing and enervating.

It should be noted, too, that automaticity of itself does not impair one's thinking capacities. When we walk, our habit centers control the action; but we can walk and think at the same time. The evil of automatic machine-feeding is negative rather than positive, in that it requires no constructive exercise of the thinking centers, and, hence, develops only the habit centers. There are, however, certain types of automatic work which are distinctly injurious because they introduce other de-

teriorating factors. For example, if the work requires that the eyes be focused constantly at one place, if the motions of the machine before the eyes be a monotonous rhythmic repetition, and if the motions of the hands in feeding the material into the machine be also rhythmic and monotonous, then a deadening hypnotic effect is produced upon the mind; such is the work of a punch-press operator.

Further, automatic work, in addition to putting the thought centers into disuse and producing a lethargizing effect, is repressive of individualty. There has been developed in each of us, through the self-directed work of our ancestors in past centuries, a natural instinct for self-expression. Prior to the day of subdivided automatic operations the worker had an outlet for his self-expression in his work; now, for the automatic worker, it must come in his idle hours, and often in forms which lead to many of our most vexing sociological problems. Unexpressive (or repressive) work is unnatural work, and must incite to mental and physical protest.

Now, we cannot reverse our present economic order of things. Work which does not require mental activity is increasing, and will continue to increase for a long time to come. The condition is here and philosophical discussion will not remove it.

The situation, then, sifts down to this. Energizing work is decreasing; enervating work is increasing. We are rapidly dividing mankind into a staff of mental workers and an army of purely physical workers. The physical workers are becoming more and more automatic, with the sure result that their minds are becoming more and more lethargic. The work itself is not character-building; on the contrary, it is repressive, and, when self-expression comes, it is hardly energizing mentally. The real menace lies in the fact that in a self-governing industrial community the minds of the majority are in danger of becoming less capable of sound and serious thought, because of lack of continuous constructive exercise while engaged in earning a livelihood.

It is evident, then, that the general law of labor must be divided into two laws, namely, the law of energizing work, which makes for progress, and the law of enervating work, which makes for retrogression. Nearly all the work still done in the open air, where there is a dependent sequence of operation, involving planning on the part of the worker, is energizing work. Specific examples may be cited in farm work, railroad work, and the building trades. Certain work done indoors, under good conditions of light and air, is also energizing; for example, the work of a toolmaker, a locomotive assembler, and a cabinet

maker. The enervating work has come through the subdivision of labor in factories, so that each worker does one thing over and over in the smallest number of cubic feet of space. This type is recognizable at once in the routine of the garment worker, the punch-press operator, the paper-box maker, and the shoe worker. On small, isolated farms, where a certain routine week by week has been established by long usage, mental development lags and the work may not be as energizing as in certain indoor occupations. In the main, however, most of the enervating work is done indoors.

Aside from the broader factors, such as climatic conditions and racial characteristics, it is safe to say that the morale of a community depends upon the kind of work it does. A rural community of about twelve thousand people, having clean political conditions, a high moral tone, few jarring families, well kept gardens, and a good average of intelligence, is a desirable place, from the manufacturer's viewpoint, in which to locate a factory. If a manufacturer locates in such a place and employs three thousand of the men, women, and children in purely *automatic, noisy, high-speed work,* the town will change very materially in one generation. Its politics will become corrupt and its morals lax; its citizenship will lose its former mental stability and fly eagerly and earnestly from one spectacular "ism" to another; its families will be on nervous edge with family discipline gone; its yards and houses will lose their tidiness; saloons will increase—in a word, it will become a "factory town." And what was once a good community, with a high community efficiency, and, therefore, a safe place in which to invest money, becomes a town of low community efficiency and a constant menace to the industry itself. Every detail of the town's life is affected. Religion lags, while the amusement parks thrive on Sunday; for, since the weekday work is repressive, an outlet for pronounced self-expression is demanded in the idle hours—or, to put it in another way, Nature goes on the defensive. The slowly upbuilt appreciation of the fine arts is quickly destroyed, for this cannot grow without harmony, orderly thought, and the desire to express ideals. Respect for law diminishes, for the law is put in the same class as an electrically wired strike fence. These significant changes are not the fault of the people who work; they are logical natural products of the work itself.

A classification of work from the most enervating to the most energizing, having in view the development of the whole man, is not only a desirable, but a necessary, thing in attempting to solve the problem of industrial education. Probably there is no type of work (if it may be

dignified by the word *work*) more enervating than a repetitive operation of complete uselessness. Even the lowest order of mentality would rebel in time against doing a thing merely to undo it, again to do it and undo it, hour after hour, day after day. Let a man, no matter how stupid, be required to carry a stone a short distance, drop it, pick it up, carry it back to its first position, and repeat this thousands of times, forward and backward, add personal isolation to the task—how long could he endure it before his spirit broke and his mind was overturned? If it were desired to disintegrate him speedily, the addition of foul air and nerve-rackng noise would accomplish it.

It will be noted that the sheer horror of this work is because it lacks meaning, fails to accomplish an end, and is purely absurd repetition. It is the absolute zero of work. Certain types of automatic industrial work are almost as enervating as this, the only difference being that the industrial work is not useless. But frequently the worker's only reason for knowing it is not useless is the fact that he would not be paid for doing it if it were; that, in some cases, is the full extent of his knowledge of why he is doing it. On the other hand, the most energizing work is probably that of a pure research man in science; especially where the building of apparatus and some outdoor investigation are necessary parts of his work. Between these two extremes lies the whole range of human labor.

For the purpose of emphasizing the different factors which make the effects of work so variable, we may devise a scale within the more usual ranges of human work, placing the most energizing at the 100 per cent. point, and the most enervating at the zero point. The 100 per cent. work selected is that of the locomotive engineer, because his work has the following elements:

(a) It is done in the open air.

(b) It provides a well-rounded physical development.

(c) The constant improvements in locomotive design and railway appliances generally require continuous mental development.

(d) Mental alertness is constantly required for emergencies.

(e) A comprehensive grasp of the whole interdependent scheme transportation is essential. This firmly establishes mental coördination.

(f) The conditions under which the same run is made are never alike.

(g) The work itself—not preachments or popular acclaim—the work itself breeds in the engineer the highest quality of good citizenship, namely, an instant willingness to sacrifice himself for the lives

in the train behind him. This makes for the best type of civic responsibility.

The zero point on the scale, or the most enervating work selected, is the work of a girl, in her formative years, in a steam laundry, when the following elements prevail:

(a) Supersaturated, vitiated air.

(b) Standing in a strained position.

(c) The work consisting of feeding one piece after another of the same kind at high speed into a machine.

(d) The hours of work being so long that fatigue poisons accumulate.

The scale is crude and lacks scientific accuracy. A statement, for example, that the work of a laster in a shoe factory is 40 per cent. energizing would be a guess. But the purpose of the scale is not so much to arrive at a percentage as to establish some standard of actual work for the purpose of diagnosis and treatment. Three investigators, analyzing the work of a laster, might classify it as 30 per cent., 40 per cent., and 50 per cent. energizing. The difference in their classifications would lead to a closer analysis, and hence to a surer treatment.

It should be noted that, where the work is done under conditions which permit the operatives to talk, without endangering them or interfering with their work, the rating is higher than where such is not the case. When we walk, our habit centers control the action, but we can walk and think at the same time. Similarly, in automatic occupations, if the motions are not too rhythmic, both of the hand and of the machine, and conversation is permitted and possible, the work is not nearly so repressive. In a certain mill, employing girls at strictly automatic work, the employees were placed facing one way, so that one operator looked upon the back of another; between adjacent operatives was a small partition. This mill had to replenish its entire force each year, because of the nervous strain of the work, until the scheme was changed to a round table plan, which encouraged conversation. After this the losses were normal.

Work cannot be classified by trades; for example, it could not be stated that the work of shoe workers was at a certain point on the scale. In this industry there are from fifty to one hundred and fifty kinds of work, depending upon the factory organization. In different shoe factories the same occupation will vary in its position on the scale by reason of environment. The elements whose effects determine the posi-

tions on the scale are principally the following: monotony, automaticity, noise, bad ventilation, personal isolation, posture, and fatigue.

It will be evident, then, that the problem of industrial education cannot be approached from the point of view of trades as defined by the materials used in the trades, as, for example, the wood-working trade, the iron-working trade, the textiles, or the garment-working trade. In a machine shop the punch-press operator has an enervating job, while the tool-room apprentice has a highly energizing job. In the foundry there is the same difference between the job of the molding machine operator and that of the skilled molder. In fact, in nearly every trade, classed by materials, this wide variation in the effects of different jobs will be found. Since the problem confronting us is the relation of education to industry, necessarily we must classify work by its educational values rather than by the material used or produced.

It must be remembered also that the whole human organism has been rapidly placed under new stresses by modern factory organization after centuries of more leisurely, quiet, diversified, and self-directed work; and their effects upon the kind of citizenship we are building must be a major consideration of the public school, in considering its connection with industry. Any policy of industrial education, which the public school adopts, must be built upon the rock-bottom basis of the mental and physical soundness necessary to the citizenship of a self-governing country. The object of all education is to make a good citizen, and, while the first duty of a good citizen is to earn his own living, there is his equal duty to be a good citizen in the civic sense; and it must be remembered that both duties require a sound body and a sound mind.

It must not be assumed for a moment that a proper measure of production on the part of each worker is at all minimized in this argument; on the contrary, a high degree of both mental ability and manual skill in industry is affirmed as being vital to the continued industrial well-being of a community; but in some cases the school, at least, must differentiate between shaping life to industry and shaping industry to life. Initially and fundamentally, industry is a machine built to simplify the basic problem of self-preservation; but modern industry is in danger of becoming an end rather than a means. In some of its phases it controls the individual, and tends to cause him to deteriorate; it ought to be controlled by him and help to build him up. It is the old story of Frankenstein. In so far, then, as industry offers work which in itself leads to increased manual skill, continuous mental development, and well pre-

EARLY GRADE BOYS IN FOUNDRY PRACTICE,
GARY, IND.

served health, the school need have no hesitancy in joining hands with it in the training of workers. But, if the skill required is an endless repetition of the same simple motions, involving no mental activity on the part of the worker, and leading to physical disorders, the school could not justify itself in initiating such manual skill. The school can not ignore, however, the fact that such work exists. It has a very definite function to perform because of the very existence of this type of work; but its function is not supplemental, it is counteractant; and ultimately its work in a counteracting way would be the most valuable work it could perform for industry. Nor will it do for the school to argue against these unfavorable conditions in modern history. Automatic and subdivided work are here to stay, and, while many of their evils can and ought to be modified in the factory, the fact remains that they must be met by school authorities, since each year thousands of children—young men and young women—go into these enervating occupations; and the amelioration of the lethargizing effects of the work is a moral obligation which cannot be dodged.

Industry wants skilled workers. By reason of its new policy of the subdivision of labor, its need is no longer for the more broadly skilled artisans; hence, its apprenticeship system is gradually disappearing; further, because of the demand on the part of managers for greater production, the superintendents and foremen feel that they cannot be bothered with apprentices. But, because a certain amount of skill is still necessary, industry turns to the school for help.

It is complained that the school no longer trains as it once did. As a matter of fact, the school never did train for industry specifically. The whole trouble is that industry has ceased training for itself. This training was originally very valuable education, and, since the youth of the country have been deprived of the advantages which the old apprenticeship system gave, it may be properly assumed that it is the function of the school to inaugurate such plans as will give manual training and which, at the same time, will make for mental development and sound physical health.

The public school must insist upon carrying out the prime function for which it is organized, namely, the sound mental, material, and moral advancement of the whole people.

### *1. Education Prior to Gainful Employment.*

a. *Elementary Training for Work Generally.*—This report deals specifically only with the vocational education of children over fourteen

years of age. Under this heading, therefore, there remains the problem of general prevocational training for children over fourteen years of age.

*Prevocational Schools for Children Over Fourteen Years of Age.*—The particular problem presented here is that of the child who does not intend to finish high school, who is not permitted by law to enter certain skilled trades until the age of 16, and who can afford to go to school only a year or two more, after which he or she must go to work. There is also the type of child who is school-sick because the bookwork of the schools is distasteful and even irksome; work in the store or factory is more attractive. The teacher realizes, too, that further abstract instruction is almost wholly a waste of time and effort; and it is evident also that, since the pupil will go to work within a year or two, some definite vocational training should be given him.

These are the hardest years of boyhood for which to plan. The boy, being a boy, wants to *do* things; he wants to be out of doors; he wants to build; he wants to earn money and assert a partial independence; he craves action; and he hates books. As a rule, he does not know what occupation he wants to go into, for the good reason that he does not know anything about the various occupations. When he goes to work he takes the first job offered, without any knowledge of the future possibilities of the work, and without any intelligent guidance based upon observation of his aptitudes.

These are also the hardest years of girlhood for which to plan. The first impulses to break away from home ties are apparent; the instinct for personal adornment is strong, and money is needed to satisfy it; the desire for a wider social activity is dominant, and school work is prosaic. Then there are the hundreds to whom the factory-age of fourteen necessarily means work. When the girl goes to work it is not, as with the boy, with the definite idea that factory or store work will be her life career. She expects to be married. As a matter of fact, the time spent by most girls in factory work is less than seven years; hence, the industrial education program for girls must be modified by the domestic phases of her later life. Important as this latter phase is, however, it can not be included in this report on industrial education.

*Prevocational Schools.*—By prevocational school is meant an industrial all-day school embracing as wide a range as possible of different types of occupations, with the school work arranged so that pupils can obtain acquaintance with the various occupations, and so that the teachers may observe their predilections and abilities. A high degree

of manual dexterity, in any one particular occupation, is not striven for. An effort is made to ascertain the particular type of work for which the pupil is adapted, and to bring his or her skill to the point where a successful beginning of an apprenticeship is possible. These schools should formulate a broad curriculum of doing and thinking for upbuilding physically, energizing mentally, for ascertaining the natural bent of a student, acquainting him with the character of work available in industry, uncovering his limitations and defects of mind and body, and giving opportunity for the discovery of exceptional talents. In the case of the girls, it is imperative that their training be more intensive (except in the purely automatic trades; and there should be no training at all in the prevocational schools for the automatic trades) than that of the boys, because of the moral obligation of society to get the young girls more quickly to a higher wage.

b. *Specific Training for a Given Trade.*—Trade Schools in the Enervating Occupations.—By trade school is meant a school which in its shops reproduces factory conditions as nearly as possible, and which aims by full time attendance of its pupils to graduate an artisan competent to enter a trade without further apprenticeship, or at most with but a short apprenticeship.

As already stated, there are two major elements of industrial efficiency which the school may consider—manual dexterity and mental development. It has been pointed out that in the enervating occupations the continuous performance of certain monotonously repeated operations leads to a stunting of mentality. As a rule, these manual operations are easily learned; the habit can be acquired in a few days or weeks. Speed in executing them is a matter of time and temperament.

This type of work, if long continued, tends ultimately to mental retardation, which is the opposite of the second element—mental development. In the purely automatic types of work, then, the public school must choose between manual dexterity and mental development. It will choose the latter, for to initiate or to increase enervating manual dexterity would not be education. Trade schools for enervating occupations cannot, therefore, be a part of the public school system. As a matter of fact, trade schools for machine-feeding occupations have never been seriously considered by school authorities.

In the Energizing Occupations.—If trade schools in the energizing occupations are set up as the solution, and if they are as efficient as they are claimed to be, their graduates will monopolize the energizing occupations, for no employer would maintain apprentice courses if an ade-

quate supply of skilled workers were available. It follows, then, that only those children who could afford to continue their schooling until they were 16 to 18 years old would get the energizing positions; the less favored ones, whom necessity or parental misguidance drives to work at an early age, would be barred from them. In effect the public school would step over into industry and close the door of the highly skilled trades to all but those who could afford to go to trade schools. The basic idea of democracy is equal opportunity, especially in the struggle for a living; and the public schools could not stand for the more favored financially and against the less favored in the field of industry.

If trade schools are *not* efficient enough to produce skilled workers, the argument for them fails. It may be contended that even the most needy parents would send their children to such schools, and that nearly all the children would, therefore, learn good trades. This would mean a large number of artisans for a small number of jobs, with the consequent ills of overproduction; for it must be remembered that energizing work is decreasing and enervating work increasing.

[1] "Further, there remains the two tests of efficiency and economy. The ability of trade schools to turn out skilled workers has been seriously questioned; this is still an open matter. But any school which attempts to do so must throw out obsolete equipment just as a well managed factory does. Therefore, if a trade school policy is adopted for a large enough number of children to make any appreciable solution, the city would be compelled to make such an initial and continuous expenditure that the imagination is staggered. The advocates of trade instruction in the public school systems sometimes evade these very essential facts by saying that the more important trades only should be taught. This latter plan at once raises two very important questions:

"1. Who shall decide which are the most important trades, and how shall public support be obtained from all sources for these few trades?

"2. Are all the children to be taught a few trades, leaving all the other trades neglected, and leaving the predilections of the children out of the question entirely? Or will only a few be trained in the more important trades, and the rest be allowed to shift for themselves as heretofore?

"Should this be attempted, it would simply be a partial solution,

[1] Fundamental Principles of Industrial Education, by Herman Schneider, April 16, 1909.

and a very small one at that, of the whole problem of industrial education. If, for instance, we have public schools teaching the plumbing, machinist, woodworking, and molding trades, what would be the solution for all the children entering the numerous other trades?

"There is, further, the taxpayer to take into consideration. Assume that A and B are citizens in moderate circumstances, and paying about the same amount of taxes. A has a boy and a girl and B has a boy and a girl. A's boy desires to be a machinist, and the public schools will train him; A's girl desires to be a stenographer, and the public schools will probably train her. B's boy wants to be a watch repairer. Has not B the same right to demand that the public schools teach his son to be a watch repairer as A has that they teach his son to be a machinist? Shall the public school system say to B's boy: you must be a machinist, plumber, molder, or woodworker, or go without a trade training? B's girl wants to be a telephone operator. Must she learn her work without any school training?

"Is it fair for the owner of the machine shop to suggest that the telephone company train its own help, when he demands that the public schools train his help?"

In view of the foregoing it should be evident that an attempt to solve the problem by putting schools for teaching enervating trades in the public school system would not be education in any good sense. To limit trade instruction to all-day schools teaching the energizing and semi-energizing trades would result in unjust discrimination against the poorer children, who could not afford to attend an all-day school, demand a tremendous expenditure of funds, and afford but an incomplete answer to the question. The big problem would still be before us.

### 2. *Education Accompanying Gainful Employment*

*The Coöperative System.*—A highly efficient system which would be entirely beyond the resources of the city would be just as futile as an economic scheme of low efficiency. Further, the adoption of any system which might be both efficient and economical, but which would be applicable to only a small percentum of the workers, would be equally futile. In solving the problem it is fair and wise and most efficient to give mental efficiency to the thousands of children already at work. This solution means, therefore, a combination of manual work in the commercial shops with school work. There are two dis-

tinct methods of obtaining this combination, namely, the coöperative system and the continuation system.

The coöperative system is based on an agreement between a group of manufacturers and a school system whereby the manufacturers agree to institute and carry on a thorough and comprehensive apprentice course in their particular trades; and in which the school agrees to give both general and specialized instruction to the apprentices. The course of work which the student receives in the shop is scheduled by the shop and must be approved by the school authorities. The school course is devised by the school authorities. In most cases the amount of school instruction is equal to the amount of shop work. The apprentices are usually divided into two sections, which alternate with each full-manned. The apprentices are paid for their work in the shop on other, for example, by weeks, so that when one section is at the shop the other is at school, and both shops and school, therefore, are always is under no burden of expense for physical equipment, except the usual laboratory equipment. There are no practice shops in the school to teach manual dexterity.

In order that the work of the school may be definitely coördinated with the work of the shop, a separate set of teachers is sometimes employed. These may be called coördinators. The shop coördinator is a teacher well versed in shop practice. He spends every morning at the school and every afternoon in the shops. His function is to make a direct coördination of the work of the shop with the instruction of the schools.

The coördinators make a careful study of each shop, and devise organization charts showing the path which a student can most profitably follow through the shop. In addition to the shop chart, a chart is made for every individual student which indicates how closely this path is followed, and why there are deviations, if any. These charts are the result of closely observed experiment on the part of the schools and the shops, and are worked out by conferences between shop coördinators and shop superintendents.

It has already been demonstrated in this country by actual experiment (at Fitchburg, Mass.) that the average young man can acquire an energizing trade and do nearly as much school work as that required in a high-school course by four years of coördinated half-time work in each. It has also been demonstrated that the alternation by weeks of student-apprentices causes no annoyance or inconvenience to the school or to the shop. Experience to the writer's knowledge has covered work

in drafting rooms, chemist shops and laboratories, machine shops, pattern shops, building trades, boiler shops, outdoor work of railroads, track, signal, bridges; courses are now being inaugurated in cloth fabric factories, grocery stores, and a variety of other occupations. Under this system, the student is assured a complete and thorough apprenticeship, since it is the function of the school to see that breadth and thoroughness of training are maintained in the commercial shop work. No girl or boy may be exploited by overzealous foremen, as the visits of coördinators prevent this. Alternating periods and alternating sections are, of course, not necessary in this system, since this is not the distinguishing feature of the plan. The essential factor is the agreement on a broad and thorough apprenticeship, with coördinated schooling, carefully checked and maintained in actual operation by the school authorities. The various coöperative plans (at Fitchburg, Mass., Solvay, N. Y., Lewis Institute, Chicago) have demonstrated that the course is commercially profitable to the manufacturer and to the student, and economical for the school.

*The Continuation System.*—Under the continuation system, the employer releases his employees of school age for a period of time (*e. g.*, one-half day or a whole day) per week to attend the public schools for definite mental instruction. The instruction given at the school is entirely under the control of the school authorities; but the school authorities have no control whatever over the shop work. The manufacturer does not agree upon any definite apprenticeship course, his only obligation being to send the workers to school for a definite number of hours per week, with or without pay. This type of school is in extensive operation in Germany, and a few have been started in this country. It has been shown in America by actual experiment (in Cincinnati) that a worker in the energizing trades who goes to school for one-half day per week, on pay, is a better producer per week than if he does not go.

Specific details of these systems will now be cited.

*The Coöperative Course in Detail.*—The coöperative system has been applied so far only to the more energizing trades, which have fairly definite plans and periods of apprenticeship, as, for example, the machinist trade, molder trade, pattern-maker trade, plumber trade. This is because the coöperative system contemplates a deliberate life choice of a trade on the part of the youth; and no boy or girl deliberately selects an automatic machine-tending job as a life job. It is selected haphazard, usually from necessity; nearly always the imme-

diate cash return is the only consideration. Coöperative plans have been devised for the more automatic trades, where these are the only trades available and where deliberate selection of a more energizing trade is out of the question; but these are just being put into operation, and hence there are no data to show whether or not they are better adapted to these trades than the continuation scheme.

Coöperative courses vary in detail to meet local and trade condition. Specific details of coöperative courses follow:

The duration of the course is determined by the length of time required for a thorough apprenticeship plus the necessary coördinated schooling—usually four years. The first year is sometimes spent wholly in school and the next three years in alternation weekly between shop and school. In some cases, the full four years are spent in weekly alternation.

The manufacturers take the student-apprentices in pairs, so that they have one of the pair always at work, and likewise the school is provided with one of the pair. Each Saturday morning the boy who has been at school that week goes to the shop in order to get a knowledge of the job on which his alternate is working, so that he will be ready to take it up Monday morning, when the shop boy goes to school for a week.

*Shop Work.*—Shop work in the commercial shop consists of instruction in all the operations necessary to the particular trade.

The apprentices receive pay for the weeks they are at work at the prevailing apprentice rates.

A candidate is usually given a trial period of one or two months preceding the opening of school, and if he likes the work and shows aptitude for the trade he takes the course; otherwise he drops out, and, if he chooses, takes up some other trade. Thus the boy is given an opportunity to find himself. During this probationary period the coördinators observe the apprentices at their work, and talk to their foremen and fellow-workmen to ascertain their aptitudes.

Objection is frequently made on the part of shop owners to the coöperative system on the assumption that alternating sets of students would cause confusion and inconvenience to the shop organization. Experience, covering a period of four years—at Fitchburg, Mass.; Solvay, N. Y.; and Chicago, Ill.—shows that this assumption is false. Emphasis is placed on this detail because it is the principal objection raised by shop superintendents when the coöperative system is proposed. The owners of shops using the coöperative system are a unit

in stating that, while trouble of this kind was anticipated, it has never developed. Shop managers have also opposed the plan for the reason that the withdrawal of a student-apprentice would leave the machine idle every other week. The actual operation of this system shows that there can never be more than one odd man in the shop, since if there are two odd men they can be combined into a new pair. Actual experience has taught that there is no difficulty in taking an odd boy from one shop and pairing him with an odd boy in another shop. In a few weeks they are alternating as smoothly as the original pair. If two boys are at different stages of development in their shop work, the smooth adjustment of their new combination is brought about through intensive instruction, by the coördinator, of the less advanced one.

The layout of the apprenticeship courses in the shop contemplates an advancement from the simple to the more complex work at the various machines and throughout the necessary departments to make a well-rounded mechanic. From the point of view of the shop, any particular kind of work has only one value, namely, the practical value of material production. From the point of view of the school, there is the added value of the mentally stimulating character of the work. For example, repetition of work in turning out certain pieces on a lathe increases the manual dexterity of an operator, and hence his output. This makes for increased production, and hence the longer the period of time the student is on a given job the greater his output. A shop superintendent, looking at an apprentice course solely from the point of view of production, would emphasize the necessity of long periods of time on repeated processes. From the point of view of the school, however, the long period of time on such processes would destroy, to a certain extent, the educational value of the apprentice course. The school would contend that a great variety of work on the lathe, with less immediate production, would, in the long run, insure a better mechanic; not only because his mental stimulation would be greater, but because he would be competent to perform a greater variety of tasks. Further, when the work is more diversified, the coördinator obtains many more practical problems, illustrating mathematics and science in the school. It will be evident, then, that in many cases the shop course will be a compromise. As a matter of actual experience in coöperative courses, it has been found that, after a year or two of operation, the shops are entirely willing to accept a plan of diversified work, as suggested by the coördinator, largely because the mental results of the greater variety of operations are clearly evident during

the apprenticeship period; and nearly every shop superintendent knows that the ability to think, on the part of the mechanic, is as fundamentally essential as his immediate ability to do.

The arrangement of shop work in the more automatic trades is a much more difficult task. Skill in a machine-feeding shop is almost entirely a matter of manual dexterity. The shoe manufacturer, for example, who has subdivided the operations of his factory into over 50 distinct kinds of work, contends that knowledge of all of the operations of a shoe factory is not necessary for the worker doing any particular piece of work. He points out that the skill in one process can be obtained in a short time; that knowledge of previous or subsequent processes in the making of a shoe is not essential to the quantity of production in any particular part of shoe making; that most of his workers are usually girls to whom the immediate cash return is more important than a thorough knowledge of the trade; and that the seasonal, the competitive, and the manually simple conditions in his industry make impossible and unnecessary a scheme of apprenticeship similar to that in carpentry, plumbing, or book-binding. It is probably true that the immediate production of the shop would not be increased, and might be decreased by a broad apprenticeship system, similar to that devised for the energizing trades mentioned, since in his trade manual dexterity is the essential thing. There are no experimental data by which to confute this argument. The theoretical contention that a broad knowledge of shoe making, on the part of, say, a laster, would increase the laster's interest in his work and make for stability of employment; lead to the discovery of better equipped and more intelligent foremen and forewomen; tend to counteract the lethargizing effects of the work; and, by shifts from one type of work to another, decrease the physically debilitating effects of nervous tension, monotony, and automaticity, can only be determined by experiment. The value to industry of a high general intelligence and sounder moral tone, which would come through the operation of such courses, must be counted in favor of a coöperative system. Unfortunately the immediate cash value of these conditions to an employer is not apparent on his books, and hence they are frequently considered by him as social questions with which industry has nothing to do.

It will be evident, then, that the introduction of coöperative courses into the more automatic trades will not be so feasible as in the more energizing trades. When, however, industry counts as an asset the broader intelligence and greater stability so necessary to a self-

HIGH SCHOOL STUDENTS, GARY, IND., IN THE CITY LABORATORY TESTING MILK

Weekly Report is Made on all Dairies Doing Business in the City

governing industrial community, and turns to the public schools for assistance, the actual planning of a shop scheme for automatic workers will not be a matter of great difficulty.

*School Work.*—Since the student reports at school every other week, a repetition of school work is necessary. What was taught to "section one" last week must be taught to "section two" this week. This does not add to the expense of instruction, since in all public school work the classes are divided into sections, and it is no more expensive to teach one section Monday of last week at 9:30 and another on Monday of this week than to teach two sections at 9:30 every week. More intensive work is possible for the week the student is at school because of his alternation of mental and physical work. Four years of experience with the coöperative system at different schools have established the remarkable fact that nearly as much work can be done in a year's time under the coöperative system as in a year's time under the regular system. It must be remembered, however, that this experience has been gained by coöperation with energizing trades. It cannot be assumed that similar conditions would prevail in coöperation with enervating trades.

School curricula and methods of instruction will always be a subject of controversy, and the application of present school courses to coöperative classes will depend upon how the present classes are taught; if, for example, the science and mathematics courses are concretely coördinated with tangible things, they will need little or no revision. If the nonscientific subjects are themselves coördinated and made vital, no essential changes will be necessary in them. The only difference will be in the added value of more direct application of the sciences and mathematics to the worker's daily task, and the closer connection of the nonscientific subjects—such as history, civics, and geography—to modern industrial activity.

Practical exemplifications of theory are brought to the school from the shop by the coördinator and by the apprentices themselves; and in a short time the regular teachers are sufficiently interested to get into closer touch with the industrial and other broader community activities—to be coördinators to a degree also. For example, if a coöperative course for silk workers were in operation, the students' attention would be called to the fact that different patterns and qualities of silk are used in different countries, and even in different parts of the same country; that the pattern of silk which would sell in Brazil would not sell in Iowa. The student would be shown that this was due to a difference in

the life, the customs, the tastes of the people, and that these in turn were a result of historical development and geographical location. The relation of silkworm culture in different countries to physiography and geography would be used to further vitalize these subjects. A course in chemistry, for example, in the case of a silk worker, would emphasize the connection of chemistry to industry through simple dye experiments, while in the case of the machinist apprentice simple metal analyses would be used. This would not mean the abridgment of a course, but the general interest in chemistry would be stimulated through specific applications to the occupations of the students. The connection of instruction in English with industry, through the necessity of writing good business letters, making accurate shop reports, describing shop processes, is too evident for elaboration.

In certain coöperative courses, however, the time allotted for school work would not permit much more than strictly technical courses. In a department store, for example, the clerks are not busy until 10 o'clock in the morning. A store can get along easily with one-half its clerks from 8 to 10 o'clock. The force is divided into two sections, one-half of whom receives instruction this week from 8 to 10 o'clock, while the other section is working; the following week the sections are changed about. In this particular instance, the students do not go to the public schools; the teachers go to the store. It is evident that it is easier to transport 20 teachers than to transport a large number of student-clerks. A number of rooms in the store, such as carpet rooms and lace rooms, are set aside during these 2 hours for the class work, the chairs being removed at 10 o'clock, and sufficient space being reserved for any business which may be necessary up to that time.

It is contended by department store owners that salesmen should know the psychology of salesmanship, and have a fairly expert knowledge of the things they are selling. They should receive, besides, a certain amount of general education. The salesmanship and the more general subjects are taught by selected teachers employed by the public schools. In order to teach the practical end, the following method has been adopted: Consider, for instance, the shoe department. If one pair of shoes costs $1.85 and another pair costs $1.95, the salesman should know where the difference of 10 cents value lies. Let us assume that this particular department store buys shoes from a firm in Brockton, Massachusetts. When it makes its next contract for shoes, it will insist that the firm selling the shoes send an expert demonstrator to its store to explain in detail all the different successive operations in shoe

making and all the different elements which make differences in cost. The tanning firm from which the shoe manufacturer buys its leather will be required to send to the store an expert who will exemplify practically to the students the different grades of leather in a hide, methods of preparation, and why one kind of leather is used in one part of a shoe, and another in some other part of a shoe. It has been found that the shoe manufacturers will very gladly enter into any scheme of this sort. He would, in fact, be a very short-sighted manufacturer who would not. This same general idea is followed in all of the other departments, such as jewelry, linen, silk, and furniture.

*The Continuation School in Detail.*—The continuation system is applicable to all trades, both energizing and enervating. The whole problem in the continuation school is the careful planning of the mental instruction so that it will best supplement the work done in the commercial shop. It will be evident that this mental instruction must vary widely for different trades, and must depend primarily upon how energizing or enervating the shop work may be. As the work approaches the 100 per cent. point on the scale of energizing and enervating work given in the forepart of this paper, the school work involves more of the science underlying the trade. For example, the carpenter apprentice will be taught practical mathematics, mechanics, simple stresses, reading of blue prints, the proper use and care of tools, etc. As the work of another occupation approaches the zero point, and becomes more enervating, the supplementary school instruction would not be the same as that in the energizing job; for, in many cases, this would be an added burden to an overstrained organism, rather than a relief. In certain high-speed repetitive processes the instruction would be planned solely to counteract the lethargizing tendencies of the work itself. Even in the same trade the instruction would vary. For example, in a factory making leather articles, one worker may be merely an automatic machine operator, while another may be on highly skilled, artistic, and energizing work. In a machine shop, the work of a punch-press operator is monotonous and lethargizing, while the work of a boy in the toolroom is highly energizing. The course of instruction given to the automatic worker would be planned solely for the stimulation of his active thinking centers. On the other hand, the skilled leather worker or toolroom apprentice would have a school course devised to teach him the science underlying his work, and to give him industrial intelligence broadly. In the case of the automatic workers, there would probably be no increase in output at first, whereas, in the case of the

skilled worker, the increase in production and the decrease in losses would be apparent.

The continuation course for the toolroom apprentice would include shop mathematics, the elements of mechanism, and writing and spelling, as they are found to be necessary; history and geography taught broadly by their connection wtih definite industrial conditions existing in the trade of the student; and, finally, courses in hygiene and civics, having to do primarily with the intimate details of city life in connection with the apprentice's daily health, transportation, pleasures, rights, and privileges.

The school work of the automatic worker presents a more difficult problem. It seems to be a well-established fact of observation that these workers have a pronounced natural craving for things that are lively and immediately interesting. They patronize the moving-picture show, the amusement parks, the dance halls; they want excitement. This is strictly in accordance with what scientific investigation would lead us to expect. The repression of the day's work prompts nature to go on the defensive, and hence the demand for something which is not dull, prosaic, or according to a fixed schedule as the daily task is, and as formal school work would be. To the unthinking, school courses which would take advantage of the opportunities offered by moving pictures, which would be especially devised to have life and color; which would counteract the dull monochrome of monotonous work; and which would be so informally conducted as not to give the feeling of compulsion, would not be education and hence an unnecessary waste of public money. Nevertheless, the school authorities are confronted with the fact that they must institute such courses, or that certain types of workers will get the same stimulation by more vicious means. The school authorities must face the fact that the usual methods of instruction will fail dismally for workers whose daily work is repressive, monotonous, and automatic, and that they must devise plans which will meet the situation which is now being met largely in a commercial way for private gain. Fundamentally the school must make the same appeal to the same desires as the shows and the parks do. This statement will probably be read with abhorrence by many school men; nevertheless, unless the situation is met in this way it will not be met at all, so far as the schools are concerned, and, since the object of education is the fostering and maintenance of good citizenship, the public schools have, in the case of the enervated worker, a very important problem. They have to take this worker as they find him with his intense and very

human desire for self-expression after daily repression, and, whether they want to or not, they must take their cue from those who are meeting this desire in a commercial way. The vicious features incident to satisfying this craving can be eliminated, and the work so organized that it will be mentally stimulating, physically upbuilding, and morally beyond criticism.

The statement that the continuation school courses for the girl at the zero point must be the most brilliant and healthful pleasure courses possible may excite ridicule, but if the critic will attempt to formulate some other scheme for, say, the laundry worker mentioned in the scale of work, which will not be an attractive and pleasurable course, he will find the one thing necessary for the success of the plan, namely, the presence and interest of the worker, absent.

There is a type of course which may be partly continuation and partly coöperative. These courses are in operation in seasonal occupations. For example, in the building trades in Chicago the apprentices work full time during the spring, summer, and fall; during the winter months, when building work is slack—by agreement between the school and the employers—they attend school for certain definite instruction. These courses may be usually classed as coöperative, inasmuch as the apprenticeship during the nine open months is agreed upon, and, during the three winter months of school, the theory of the work is taught.

Particular emphasis is placed upon the fact that no hard and fast rule for the operation, in detail, of the coöperative and continuation courses can be made. There is in each case a most efficient plan, alike for the employer and the employee, and each type of occupation must be studied to ascertain the proper relative amounts of shop and school work, time of attendance, curriculum, and methods of instruction.

### *(V)—How to Inaugurate Continuation and Coöperative Schools*

Continuation courses may be instituted in two ways: First, by compelling the employer to send his working people, between certain age limits, to the schools for a certain percentage of the working hours; and, secondly, by inducing the manufacturer, by voluntary action, to consent to coöperation with the public schools. Since the coöperative system involves an agreement on the part of the employer to maintain a thorough apprentice system, it can hardly be made compulsory by legal enactment unless laws governing apprenticeship are also enacted.

Under the first plan the establishment of the continuation school

may be made mandatory by legislative action, both for the employer and for the public school. In Wisconsin, for example, the employer is required to send all his employees, between the ages of 14 and 16, for five hours of instruction per week during working hours. The law further limits the number of working hours per week for these children to 48, including the five hours for school. As a result of this law, some children were discharged, either to be idle or to go back to school for full-time instruction, until the law permits them to work full time in the shops. The Ohio law makes it obligatory on the part of the manufacturer to send his employees between certain ages for a certain amount of instruction to such continuation schools as the public school authorities may deem it advisable to inaugurate. This plan permits the school to make a study of industrial conditions and to govern the solution accordingly. Under either compulsory system the manufacturer has no option in the matter of sending his employees between certain ages to the public schools.

The second system, in which action by the manufacturers is voluntary, is as a rule harder to put into operation. The manufacturer must be convinced that 4 or 8 hours per week in the schoolroom will so increase the efficiency of the young worker that production will not decrease; at least that it will not decrease sufficiently to make it a serious element in his competition with another employer who does not permit his employees to attend school. In some industries, a competitor would suffer for a time and possibly indefinitely by the continuation system if he adopted it and his competitor did not. This is especially true of an industry such as the shoe industry, where a large number of juveniles are employed. In the voluntary schools, so far inaugurated in this country, practically all of the employers in a given industry have agreed mutually to send their juvenile workers to school for a certain period of time; but they are still at a disadvantage in competing with outside employers whose workers work full time. In the more highly skilled trades, such as the machinist trade and the patternmaker trade, it has been shown (in Cincinnati) that the production per week is not lessened by the attendance at school. In the Cincinnati plan, the employers pay the apprentices for the time at school just as if they were at their machines.

In the voluntary system, the first problem confronting the school men desirous of establishing continuation or coöperative courses is to get the interest of the manufacturers in each particular trade. In nearly every line of industry the employers usually have an organization

with a secretary and a central office. Through this secretary the manufacturers are approached by letter, by individual visits, and by meetings, to obtain their consent to some form of industrial education for their employees. In nearly every case it will be found that there are enough employers who appreciate sufficiently the seriousness of modern industrial conditions to give the school men a good-sized class. To begin continuation courses requires a considerable amount of study in order to determine the time of day and time of week that the children are to be taught, the subject matter to be given, and the method of its presentation; and there is always the difficult matter of finding the proper teachers. This latter difficulty has been used as an argument against both the coöperative and the continuation systems. It can be used, however, with equal force against the day trade school, for, as a matter of fact, the trade school teacher ought to be more efficient than a continuation school teacher, since he has both theory and practice to teach, while the continuation school teacher has only the theory to teach.

It will be seen then that the formation of coöperative and continuation schools is a slow process, if efficiency is to obtain; and that in many cases legal enactment is not necessary for their inauguration. Of course, there may be localities in which conditions are such that no manufacturer would coöperate with the schools voluntarily, or there may be certain groups of manufacturers in certain trades, for example, in the seasonal trades, none of whom would consent to the plan. Under these conditions, the compulsory system is necessary.

The second broad question to settle is as to the type of school, whether coöperative or continuation. From a manufacturer's viewpoint, the coöperative scheme offers the advantage of keeping his machine full-manned all the time. Actual experience has demonstrated, as heretofore stated, that there is no conflict, confusion, or commercial loss arising from the working in alternate weeks of two groups of workers; but, again, the coöperative system contemplates a broad and thorough apprenticeship in the store, shop, or office. Manufacturers in favor of specialization are sometimes opposed to this phase of the system. Then, again, the number of children who can afford to go to school and to shop on the half-time plan is limited; so that, aside from other considerations, both plans will have to be inaugurated. Generally speaking, it will be found that the coöperative courses will be more easily organized in the energizing trades. It will be argued that the coöperative courses, therefore, are subject to the same fundamental

objection that applies to the full-time trade school, and that the more favored will therefore possess the energizing trades. A little analysis will show this to be fallacious. In the first place, a coöperative system is applicable, with a well-arranged apprenticeship, to the enervating trades, and, in the second place, if a worker cannot afford to enter the coöperative course the apprenticeship in the commercial shop is open to him just the same; and, further, at a later date, when his wages are higher, the coöperative or continuation courses are always available. The continuation scheme will be more largely used than the coöperative system because the bread-and-butter necessities will make it the only feasible plan for a large number. The coöperative scheme presents the better combination of a good apprenticeship, coördinated instruction, and a more advanced mental development.

From the point of view of the school, the coöperative course is much more difficult of operation than the continuation course. It requires a careful analysis of shop work in order to perfect a proper arrangement of the apprentice course, necessitates a carefully built internal organization for the coördination of theory and practice, and demands constant care and attention to insure its smooth operation. Unlike the usual public school course, it cannot be started in September and allowed to run more or less by its own momentum until June. The executive work of a coöperative course requires daily attention to a variety of details, just as any business does. But it has the unquestioned advantage of placing a swift and sure check on the efficiency of the instruction given in the school, and inevitably it leads to a comprehensive revision of many of the science and mathematics courses as they are now taught. In fact, this check on the efficiency of school instruction is one of the most valuable features of the coöperative course from the school man's point of view.

Briefly then, in choosing between coöperative and continuation courses the decision will largely be determined by the relative poverty of a community, the attitude of the manufacturers (assuming no legal enactment) to the inauguration of thorough apprenticeships, and the willingness of the schools to undertake a varied and more exacting system of instruction.

One evening, about a year prior to the writing of this, the writer had two addresses to make in New York City. The first was before a body of school teachers and the second before a group of manufacturers. Prior to going on the platform at the school teachers' meeting he was requested not to make an attack upon trade schools; that is,

schools which attempt to teach trades by full-time attendance at school. He was told that, while it was generally conceded that the coöperative and continuation schools are the most efficient, they are not possible in New York City because the employers would not agree to their adoption, and that hence only the trade school was possible for New York City. At the second meeting, after an explanation of the coöperative and continuation systems, there was a lively discussion in which one manufacturer after another expressed a desire for these courses—but said that they were impossible because of the attitude of the school people. The attitude of the schools was assumed to be one of antagonism toward industry and a lack of concern toward industrial efficiency.

It has been conclusively demonstrated that the school and shop can work together if the one common ground will be the mutually safe ground of the mental, physical, and the moral advancement of those who work. This will seem to the superficial critic a too ideal basis on which to do business in this day and generation. He will probably agree that it is a nice scheme to have in mind, but an impossible one upon which to operate. There is but one satisfactory answer to this, namely, that the thing is being done and is being done satisfactorily.

# SCIENCE AND INVENTION

## RESEARCHES AND EXPERIMENTS IN AERIAL NAVIGATION

By Samuel Pierpont Langley

The subject of flight interested me as long ago as I can remember anything, but it was a communication from Mr. Lancaster, read at the Buffalo meeting of the American Association for the Advancement of Science, in 1886, which aroused my then dormant attention to the subject. What he said contained some remarkable but apparently mainly veracious observations on the soaring bird, and some more or less paradoxical assertions, which caused his communication to be treated with less consideration than it might otherwise have deserved. Among these latter was a statement that a model, somewhat resembling a soaring bird, wholly inert, and without any internal power, could, nevertheless, under some circumstances, advance against the wind without falling; which seemed to me then, as it did to members of the association, an utter impossibility, but which I have since seen reason to believe is, within limited conditions, theoretically possible.

I was then engaged in the study of astrophysics at the Observatory in Allegheny, Pennsylvania. The subject of mechanical flight could not be said at that time to possess any literature, unless it were the publications of the French and English aeronautical societies, but in these, as in everything then accessible, fact had not yet always been discriminated from fancy. Outside of these, almost everything was even less trustworthy; but though, after I had experimentally demonstrated certain facts, anticipations of them were found by others on historical research, and though we can now distinguish in retrospective examination what would have been useful to the investigator if he had known it to be true, there was no test of the kind to apply at the time. I went to work, then, to find out for myself, and in my own way, what amount of mechanical power was requisite to sustain a given weight in the air and make it advance at a given speed, for this seemed to be an inquiry which must necessarily precede any attempt at mechanical flight, which was the very remote aim of my efforts.

The work was commenced in the beginning of 1887 by the construction, at Allegheny, of a turntable of exceptional size, driven by a steam engine, and this was used during three years in making the "Experiments in Aerodynamics," which were published by the Smithsonian Institution under that title in 1891. Nearly all the conclusions reached were the result of direct experiment in an investigation which aimed to take nothing on trust. Few of them were then familiar, though they have since become so, and in this respect knowledge has advanced so rapidly, that statements which were treated as paradoxical on my first enunciation of them are now admitted truisms.

May I quote from the introduction to this book what was said in 1891?

"I have now been engaged since the beginning of the year 1887 in experiments on an extended scale for determining the possibilities of, and the conditions for, transporting in the air a body whose specific gravity is greater than that of the air, and I desire to repeat my conviction that the obstacles in its way are not such as have been thought; that they lie more in such apparently secondary difficulties, as those of guiding the body so that it may move in the direction desired and ascend or descend with safety, than in what may appear to be primary difficulties, due to the air itself," and, I added, that in this field of research I thought that we were, at that time (only six years since), "in a relatively less advanced condition than the study of steam was before the time of Newcomen." It was also stated that the most important inference from those experiments as a whole was that mechanical flight was possible with engines we could then build, as one horsepower rightly applied could sustain over 200 pounds in the air at a horizontal velocity of somewhat over 60 feet a second.

As this statement has been misconstrued, let me point out that it refers to surfaces, used without guys or other adjuncts, which would create friction; that the horsepower in question is that actually expended in the thrust, and that it is predicated only on a rigorously horizontal flight. This implies a large deduction from the power in the actual machine, where the brake horsepower of the engine, after a requisite allowance for loss in transmission to the propellers and for their slip on the air, will probably be reduced to from one-half to one-quarter of its nominal amount; where there is great friction from the enforced use of guys and other adjuncts; but, above all, where there is no way to insure absolutely horizontal flight in free air. All these things allowed for, however, since it seemed to me possible to provide

an engine which should give a horsepower for something like 10 pounds of weight, there was still enough to justify the statement that we possessed in the steam engine, as then constructed or in other heat engines, more than the indispensable power, though it was added that this was not asserting that a system of supporting surfaces could be securely guided through the air or safely brought to the ground, and that these and like considerations were of quite another order, and belonged to some inchoate art which I might provisionally call *aerdromics*.

The first stage of the investigation was now over, so far as that I had satisfied myself that mechanical flight was possible with the power we could hope to command, if only the art of directing that power could be acquired.

The second stage (that of the acquisition of this art) I now decided to take up. It may not be out of place to recall that at this time, only six years ago, a great many scientific men treated the whole subject with entire indifference, as unworthy of attention, or as outside of legitimate research, the proper field of the charlatan, and one on which it was scarcely prudent for a man with a reputation to lose to enter.

The record of my attempts to acquire the art of flight may commence with the year 1889, when I procured a stuffed frigate bird, a California condor, and an albatross, and attempted to move them upon the whirling table at Allegheny. The experiments were very imperfect and the records are unfortunately lost, but the important conclusion to which they led was that a stuffed bird could not be made to soar except at speeds which were unquestionably very much greater than what served to sustain the living one, and the earliest experiments and all subsequent ones with actually flying models have shown that thus far we can not carry nearly the weights which Nature does to a given sustaining surface without a power much greater than she employs. At the time these experiments were begun, Penaud's ingenious but toy-like model was the only thing which could sustain itself in the air for even a few seconds, and calculations founded upon its performance sustained the conclusion that the amount of power required in actual free flight was far greater than that demanded by the theoretical enunciation. In order to learn under what conditions the aerodrome should be balanced for horizontal flight, I constructed over thirty modifications of the rubber-driven model, and spent many months in endeavoring from these to ascertain the laws of "balancing;" that is, of stability leading to horizontal flight. Most of these models had two propellers, and it was extremely difficult to build them light and strong enough. Some

of them had superposed wings; some of them curved and some plane wings; in some the propellers were side by side; in others one propeller was at the front and the other at the rear, and so every variety of treatment was employed, but all were at first too heavy, and only those flew successfully which had from 3 to 4 feet of sustaining surface to a pound of weight, a proportion which is far greater than Nature employs in the soaring bird, where in some cases less than half a foot of sustaining surface is used to a pound. It had been shown in the "Experiments in Aerodynamics" that the center of pressure on an inclined plane advancing was not at the center of figure, but much in front of it, and this knowledge was at first nearly all I possessed in balancing these early aerodromes. Even in the beginning, also, I met remarkable difficulty in throwing them into the air, and devised numerous forms of launching apparatus which were all failures, and it was necessary to keep the construction on so small a scale that they could be cast from the hand.

The earliest actual flights with these were extremely irregular and brief, lasting only from three to four seconds. They were made at Allegheny in March, 1891, but these and all subsequent ones were so erratic and so short that it was possible to learn very little from them. Penaud states that he once obtained a flight of thirteen seconds. I never got as much as this, but ordinarily little more than half as much, and came to the conclusion that in order to learn the art of mechanical flight it was necessary to have a model which would keep in the air for at any rate a longer period than these, and move more steadily. Rubber twisted in the way that Penaud used it will practically give about 300 foot-pounds to a pound of weight, and at least as much must be allowed for the weight of the frame on which the rubber is strained. Twenty pounds of rubber and frame, then, would give 3,000 foot-pounds, or 1 horsepower for less than six seconds. A steam engine having apparatus for condensing its steam, weighing in all 10 pounds, and carrying 10 pounds of fuel, would possess in this fuel, supposing that but one-tenth of its theoretical capacity is utilized, many thousand times the power of an equal weight of rubber, or at least 1 horsepower for some hours. Provided the steam could be condensed and the water reused, then the advantage of the steam over the spring motor was enormous, even in a model constructed only for the purpose of study. But the construction of a steam-driven aerodrome was too formidable a task to be undertaken lightly, and I examined the capacities of condensed air, carbonic-acid gas, of various applications of

electricity, whether in the primary or storage battery, of hot-water engines, of inertia motors, of the gas engine, and of still other material. The gas engine promised best of all in theory, but it was not yet developed in a suitable form. The steam engine, as being an apparently familiar construction, promised best in practice, but in taking it up, I, to my cost, learned that in the special application to be made of it, little was really familiar and everything had to be learned by experiment. I had myself no previous knowledge of steam engineering, nor any assistants other than the very capable workmen employed. I well remember my difficulties over the first aerodrome (No. 0), when everything, not only the engine, but the boilers which were to supply it, the furnaces which were to heat it, the propellers which were to advance it, the hull which was to hold all these—were all things to be originated, in a construction which, as far as I knew, had never yet been undertaken by anyone.

It was necessary to make a beginning, however, and a compound engine was planned which, when completed, weighed about 4 pounds, and which could develop rather over a horsepower with 60 pounds of steam, which it was expected could be furnished by a series of tubular boilers arranged in "bee-hive" form and the whole was to be contained in a hull about 5 feet in length and 10 inches in diameter. This hull was, as in the construction of a ship, to carry all adjuncts. In front of it projected a steel rod, or bowsprit, about its own length, and one still longer behind. The engines rotated two propellers, each about 30 inches in diameter, which were on the end of long shafts disposed at an acute angle to each other and actuated by a single gear driven from the engine. A single pair of large wings contained about 50 square feet, and a smaller one in the rear about half as much, or in all some 75 feet, of sustaining surface, for a weight which it was expected would not exceed 25 pounds.

Although this aerodrome was in every way a disappointment, its failure taught a great many useful lessons.

In 1892 another aerodrome (No. 1), which was to be used with carbonic acid gas, or with compressed air, was commenced. The weight of this aerodrome was a little over 4½ pounds, and the area of the supporting surfaces 6½ square feet. The engines developed but a small fraction of a horsepower, and they were able to give a dead lift of only about one-tenth of the weight of the aerodrome, giving relatively less power to weight than that obtained in the large aerodrome already condemned.

Toward the close of this year was taken up the more careful study of the position of the center of gravity with reference to the line of thrust from the propellers, and to the center of pressure. The center of gravity was carried as high as was consistent with safety, the propellers being placed so high, with reference to the supporting wings, that the intake of air was partly from above and partly from below these latter. The lifting power (*i. e.*, the dead lift) of the aerodromes was determined in the shop by a very useful contrivance which I have called the "pendulum," which consists of a large pendulum which rests on knife edges, but is prolonged above the points of support, and counterbalanced so as to present a condition of indifferent equilibrium. Near the lower end of this pendulum the aerodrome is suspended, and when power is applied to it, the reaction of the propellers lifts the pendulum through a certain angle. If the line of thrust passes through the center of gravity, it will be seen that the sine of this angle will be the fraction of the weight lifted, and thus the dead-lift power of the engines becomes known. Another aerodrome was built, but both, however constructed, were shown by this pendulum test to have insufficient power, and the year closed with disappointment.

Aerodrome No. 3 was of stronger and better construction, and the propellers, which before this had been mounted on shafts inclined to each other in a V-like form, were replaced by parallel ones. Boilers of the Serpolet type (that is, composed of tubes of nearly capillary section) were experimented with at great cost of labor and no results; and they were replaced with coil boilers. For these I introduced, in April, 1893, a modification of the ælopile blast, which enormously increased the heat-giving power of the fuel (which was then still alcohol), and with this blast for the first time the boilers began to give steam enough for the engines. It had been very difficult to introduce force pumps which would work effectively on the small scale involved, and after many attempts to dispense with their use by other devices, the acquisition of a sufficiently strong pump was found to be necessary in spite of its weight, but was only secured after long experiment. It may be added that all the aerodromes from the very nature of their construction were wasteful of heat, the industrial efficiency little exceeding half of 1 per cent, or from one-tenth to one-twentieth that of a stationary engine constructed under favorable conditions. This last aerodrome lifted nearly 30 per cent of its weight upon the pendulum, which implied that it could lift much more than its weight when running on a horizontal track, and its engines were capable of running its 50-centimeter pro-

pellers at something over 700 turns per minute. There was, however, so much that was unsatisfactory about it, that it was deemed best to proceed to another construction before an actual trial was made in the field, and a new aerodrome, designated as No. 4, was begun. This last was an attempt, guided by the weary experience of preceding failures, to construct one whose engines should run at a much higher pressure than heretofore, and be much more economical in weight. The experiments with the Serpolet boilers having been discontinued, the boiler was made with a continuous helix of copper tubing, which, as first employed, was about three millimeters internal diameter; and it may be here observed that a great deal of time was subsequently lost in attempts to construct a more advantageous form of boiler for the actual purposes than this simple one, which, with a larger coil tube, eventually proved to be the best; so that later constructions have gone back to this earlier type. A great deal of time was lost in these experiments from my own unfamiliarity with steam engineering, but it may also be said that there was little help either from books or from counsel, for everything was here *sui generis,* and had to be worked out from the beginning. In the construction which had been reached by the middle of the third year of experiment, and which has not been greatly differed from since, the boiler was composed of a coil of copper in the shape of a hollow helix, through the center of which the blast from the ælopile was driven, the steam and water passing into a vessel I called the "separator," whence the steam was led into the engines at a pressure of from 70 to 100 pounds (a pressure which has since been considerably exceeded).

From the very commencement of this long investigation the great difficulty was in keeping down the weight, for any of the aerodromes could probably have flown had they been built light enough, and in every case before the construction was completed the weight had so increased beyond the estimate, that the aerodrome was too heavy to fly, and nothing but the most persistent resolution kept me in continuing attempts to reduce it after further reduction seemed impossible. Toward the close of the year (1893) I had, however, finally obtained an aerodrome with mechanical power, as it seemed to me, to fly, and I procured, after much thought as to where this flight should take place, a small house boat, to be moored somewhere in the Potomac; but the vicinity of Washington was out of the question, and no desirable place was found nearer than 30 miles below the city. It was because it was known that the aerodrome might have to be set off in the face of a

wind, which might blow in any direction, and because it evidently was at first desirable that it should light in the water rather than on the land, that the house boat was selected as the place for the launch. The aerodrome (No. 4) weighed between 9 and 10 pounds, and lifted 40 per cent of this on the pendulum with 60 pounds of steam pressure, a much more considerable amount than was theoretically necessary for horizontal flight. And now the construction of a launching apparatus, dismissed for some years, was resumed. Nearly every form seemed to have been experimented with unsuccessfully in the smaller aerodromes. Most of the difficulties were connected with the fact that it is necessary for an aerodrome, as it is for a soaring bird, to have a certain considerable initial velocity before it can advantageously use its own mechanism for flight, and the difficulties of imparting this initial velocity with safety are surprisingly great, and in the open air are beyond all anticipation.

I pass over a long period of subsequent baffled effort, with the statement that numerous devices for launching were tried in vain and that nearly a year passed before one was effected.

Six trips and trials were made in the first six months of 1894 without securing a launch. On the 24th of October a new launching piece was tried for the first time, which embodied all the requisites whose necessity was taught by previous experience, and, saving occasional accidents, the launching was from this time forward accomplished with comparatively little difficulty.

The aerodromes were now for the first time put fairly in the air, and a new class of difficulties arose, due to a cause which was at first obscure — for two successive launches of the same aerodrome, under conditions as near alike as possible, would be followed by entirely different results. For example, in the first case it might be found rushing, not falling, forward and downward into the water under the impulse of its own engines; in the second case, with every condition from observation apparently the same, it might be found soaring upward until its wings made an angle of 60 degrees with the horizon, and, unable to sustain itself at such a slope, sliding backward into the water.

After much embarrassment the trouble was discovered to be due to the fact that the wings, though originally set at precisely the same angle in the two cases, were irregularly deflected by the upward pressure of the air, so that they no longer had the form which they appeared to possess but a moment before they were upborne by it, and so that a very minute difference, too small to be certainly noted, exaggerated by

this pressure, might cause the wind of advance to strike either below or above the wing and to produce the salient difference alluded to. When this was noticed all aerodromes were inverted, and sand was dredged uniformly over the wings until its weight represented that of the machine. The flexure of the wings under those circumstances must be nearly that in free air, and it was found to distort them beyond all anticipation. Here commences another series of trials, in which the wings were strengthened in various ways, but in none of which, without incurring a prohibitive weight, was it possible to make them strong enough. Various methods of guying them were tried, and they were rebuilt on different designs—a slow and expensive process. Finally, it may be said, in anticipation (and largely through the skill of Mr. Reed, the foreman of the work), the wings were rendered strong enough without excessive weight, but a year or more passed in these and other experiments.

In the latter part of 1894 two steel aerodromes had already been built, which sustained from 40 to 50 per cent of their dead-lift weight on the pendulum, and each of which was apparently supplied with much more than sufficient power for horizontal flight (the engine and all the moving parts furnishing over one horsepower at the brake weighed in one of these but 26 ounces); but it may be remarked that the boilers and engines in lifting this per cent of the weight did so only at the best performance in the shop, and that nothing like this could be counted upon for regular performance in the open. Every experiment with the launch, when the aerodrome descended into the water, not gently, but impelled by the misdirected power of its own engines, resulted at this stage in severe strains and local injury, so that repairing, which was almost rebuilding, constantly went on; a hard but necessary condition attendant on the necessity of trial in the free air. It was gradually found that it was indispensable to make the frame stronger than had hitherto been done, though the absolute limit of strength consistent with weight seemed to have been already reached, and the year 1895 was chiefly devoted to the labor on the wings and what seemed at first the hopeless task of improving the construction so that it might be stronger without additional weight, when every gram of weight had already been scrupulously economized. With this went on attempts to carry the effective power of the burners, boilers, and engines further, and modification of the internal arrangement and a general disposition of the parts such that the wings could be placed further forward or backward at pleasure, to more readily meet

the conditions necessary for bringing the center of gravity under the center of pressure. So little had even now been learned about the system of balancing in the open air, that at this late day recourse was again had to rubber models, of a different character, however, from those previously used; for in the latter the rubber was strained, not twisted. These experiments took up an inordinate time, though the flight obtained from the models thus made was somewhat longer and much steadier than that obtained with the Penaud form, and from them a good deal of valuable information was gained as to the number and position of the wings and as to the effectiveness of different forms and dispositions of them. By the middle of the year a launch took place with a brief flight, where the aerodrome shot down into the water after a little over 50 yards. It was immediately followed by one in which the same aerodrome rose at a considerable incline and fell backward with scarcely any advance after sustaining itself rather less than 10 seconds, and these and subsequent attempts showed that the problem of disposing of the wings so that they would not yield and of obtaining a proper "balance" was not yet solved.

Briefly it may be said that the year 1895 gave small results for the labor with which it was filled, and that at its close the outlook for further substantial improvement seemed to be almost hopeless, but it was at this time that final success was drawing near. Shortly after its close I became convinced that substantial rigidity had been secured for the wings; that the frame had been made stronger without prohibitive weight, and that a degree of accuracy in the balance had been obtained which had not been hoped for. Still there had been such a long succession of disasters and accidents in the launching that hope was low when success finally came.

### THE AERODROMES IN FLIGHT

The successful flights of Dr. Langley's aerodrome were witnessed by Dr. Bell, and described by him as follows:

"Through the courtesy of Dr. S. P. Langley, secretary of the Smithsonian Institution, I have had, on various occasions, the privilege of witnessing his experiments with aerodromes, and especially the remarkable success attained by him in experiments made upon the Potomac river on Wednesday, May 6, 1896, which led me to urge him to make public some of these results.

"I had the pleasure of witnessing the successful flight of some of

these aerodromes more than a year ago, but Dr. Langley's reluctance to make the results public at that time prevented me from asking him, as I have done since, to let me give an account of what I saw.

"On the date named two ascensions were made by the aerodrome, or so-called 'flying machine,' which I will not describe here further than to say that it appeared to me to be built almost entirely of metal, and driven by a steam engine which I have understood was carrying fuel and a water supply for a very brief period, and which was of extraordinary lightness.

"The absolute weight of the aerodrome, including that of the engine and all appurtenances, was, as I was told, about 25 pounds, and the distance from tip to tip of the supporting surfaces was, as I observed, about 12 or 14 feet. The method of propulsion was by aerial screw propellers, and there was no gas or other aid for lifting it in the air except its own internal energy.

"On the occasion referred to, the aerodrome, at a given signal, started from a platform about 20 feet above the water, and rose at first directly in the face of the wind, moving at all times with remarkable steadiness, and subsequently swinging around in large curves of, perhaps, a hundred yards in diameter, and continually ascending until its steam was exhausted, when, at a lapse of about a minute and a half, and at a height which I judged to be between 80 and 100 feet in the air, the wheels ceased turning, and the machine, deprived of the aid of its propellers, to my surprise did not fall, but settled down so softly and gently that it touched the water without the least shock, and was in fact immediately ready for another trial.

"In the second trial, which followed directly, it repeated in nearly every respect the actions of the first, except that the direction of its course was different. It ascended again in the face of the wind, afterwards moving steadily and continually in large curves accompanied with a rising motion and a lateral advance. Its motion was, in fact, so steady, that I think a glass of water on its surface would have remained unspilled. When the steam gave out again, it repeated for a second time the experience of the first trial when the steam had ceased, and settled gently and easily down. What height it reached at this trial I can not say, as I was not so favorably placed as in the first; but I had occasion to notice that this time its course took it over a wooded promontory, and I was relieved of some apprehension in seeing that it was already so high as to pass the tree tops by 20 or 30 feet. It reached the water one minute and thirty-one seconds from the time it started,

at a measured distance of over 900 feet from the point at which it rose.

"This, however, was by no means the length of its flight. I estimated from the diameter of the curve described, from the number of turns of the propellers as given by the automatic counter, after due allowance for slip, and from other measures, that the actual length of flight on each occasion was slightly over 3,000 feet. It is at least safe to say that each exceeded half an English mile.

"From the time and distance it will be noticed that the velocity was between 20 and 25 miles an hour, in a course which was taking it constantly 'up hill.' I may add that on a previous occasion I have seen a far higher velocity attained by the same aerodrome when its course was horizontal.

"I have no desire to enter into detail further than I have done, but I can not but add that it seems to me that no one who was present on this interesting occasion could have failed to recognize that the practicability of mechanical flight had been demonstrated.

"ALEXANDER GRAHAM BELL."

## THE UNITED STATES WEATHER BUREAU

BY MAJOR HENRY B. HERSEY, DISTRICT FORECASTER, U. S. WEATHER BUREAU

An important feature of the great industrial development of the country following the close of the Civil War was the building of railroads and telegraph lines over western states and territories. This improved means of communication brought to the attention of the general public the fact that severe storms and cold-waves in the western country were usually followed within a day or two by similar conditions in the East. This soon led to a demand by the Marine and Commercial interests of the country for the Federal Government to establish a service to give warning of the approach of dangerous storms. Such action had already been recommended by a few of the most alert and progressive scientists who had made a study of storm

movements, but it was not until the large and rapidly growing business interests began to call for the service that Congress gave heed and provided for the work. The first step taken in response to this demand was the following joint resolution passed by the House of Representatives and Senate, and signed by President Grant on February 9, 1870:

"Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, that the Secretary of War be, and hereby is, authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on the seacoast, by magnetic telegraph and marine signals, of the approach and force of storms."

This short resolution marked the beginning of what has since developed into the greatest meteorological service in the world, the greatest in extent of territory covered, the greatest in strength of personnel, and by far the greatest in value of service rendered to the public.

The work of establishing the service was placed by the Secretary of War in the hands of Brigadier-General Albert J. Myer, Chief Signal Officer of the Army, who, in March, 1870, took up the work of organization vigorously. A number of noncommissioned officers from the line and staff corps of the Army were transferred and appointed observer-sergeants, and a training school was established to instruct them in their new duties as weather observers to which they were assigned. This work progressed as rapidly as could be expected, and General Myer, in his annual report to the Secretary of War for the fiscal year ending June 30, 1871, had the following statement:

"On November 1, 1870, at 7:35 a. m., the first systematized, synchronous, meteoric reports ever taken in the United States were read from the instruments by the observer-sergeants of the signal service at twenty-four stations, and placed upon the telegraphic wires for transmission.

"With the delivery of these reports at Washington, and at the other cities and ports to which it had been arranged they should be sent, which delivery was made by 9 a. m., commenced the practical working of this division of the signal service in this country.

"The pleasant feeling with which the service was everywhere recognized, and the aid everywhere tendered and rendered the office, are known to the Secretary of War.

* * * * * * *

"In November, 1870, Professor I. A. Lapham, of Milwaukee, a meteorologist well known throughout the lake region, was employed as assistant to the Chief Signal Officer, and stationed at Chicago, with special reference to the supervision of the signal service on the lakes.

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"The services of Professor Cleveland Abbe, A. M., assistant to the Chief Signal Officer, as meteorologist, were secured on the 3d of January, 1871, since which date he has been on duty in this office.

"Professor Thompson B. Maury, A. M., entered upon service as assistant in the office June 18, 1871."

Second Lieutenant A. W. Greely, afterward Chief of the Service, was also assigned to duty in the Weather Service. And by June 30, 1871, eighty-three observer-sergeants were on duty and fifty-six stations were in operation. Three observations a day were being made at each station and telegraphed to Washington and a few other large cities, and the information given to the press and public.

Congress made provision in the annual appropriation bills from time to time for the extension of the work of the Bureau, especially along lines that would increase its value to the agricultural interests. Under the management of the various Army officers who served at its head, the Bureau made a steady and substantial growth.

After a time a feeling arose that, as the work of the Bureau was of a scientific nature and had no connection with military signaling or other military duties, that conditions would be more favorable for its future development if it were taken out of the Army and placed in one of the other departments under civilian management. Congress gave its approval to these views by an act which was approved October 1, 1890, providing for the transfer of the Weather Bureau from the War Department to the Department of Agriculture, to take effect July 1, 1891. This act, which may be considered the organic act providing for the status of the Weather Bureau under the Secretary of Agriculture, defines its duties in the following words:

"The Chief of the Weather Bureau, under the direction of the Secretary of Agriculture, shall have charge of forecasting the weather;

the issue of storm warnings; the display of weather and flood signals for the benefit of agriculture, commerce and navigation; the gauging and reporting of rivers; the maintenance and operation of seacoast telegraph lines and the collection and transmission of marine intelligence for the benefit of commerce and navigation; the reporting of temperature and rainfall conditions for the cotton interests; the display of frost, cold wave, and other signals; the distribution of meteorological information in the interest of agriculture and commerce; and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or are essential for the proper execution of the foregoing duties."

Under the Secretary of Agriculture the Bureau has made remarkable progress. Its work has been greatly extended, and its benefits have been brought closer to the public, until there is hardly any important industry which does not derive material assistance from the information placed at its disposal by the Weather Bureau.

Approximately two hundred regular Weather Bureau stations are maintained, covering the United States, the West Indies, Hawaii and Alaska. Each station has a very complete instrumental equipment, an interesting feature of this being instruments arranged by means of clock-work and electrical connections to automatically record the most important elements of the weather. These self-recording instruments make a continuous record, day and night, of the atmospheric pressure, the temperature, the velocity and direction of the wind, the hours of sunshine, the humidity of the air, and the amount of rainfall to the hundredth of an inch. These stations make observations twice a day, at 8 a. m. and 8 p. m., 75th meridian time, and telegraph reports of same to the Central Office at Washington and to other centers authorized to receive them. For the purpose of handling these reports expeditiously, certain wires of the telegraph companies are connected up in special circuits at 8 a. m. and 8 p. m., and so arranged that one operator sends, and operators at all receiving stations on the circuit take down the reports. In order to make the reports brief, they are sent in special cipher. So well are these plans carried out that practically all reports are received at the various offices using them within an hour from the time the observations are made. At Washington and most of the other large cities a chart is prepared showing graphically the weather conditions prevailing over the country at the time of the morning observation. A summary of the condi-

tions is also written for the newspapers, and a forecast for the locality and for the state is prepared, covering a period for the ensuing thirty-six hours or longer. All of this work is done, and the maps, forecasts, and information are printed and ready for the public over the whole country in about two and a half hours from the time the observers were reading the instruments. By reciprocal arrangements with other countries reports are received daily from Canada, Great Britain, Germany, France, Russia, including Siberia, Japan, China, the Philippines, Iceland, the Azores, Norway and Spitzbergen, enabling the forecast centers to prepare daily maps for study covering the northern hemisphere.

The country is at present, 1914, divided for purposes of weather forecasting into six districts, with centers at Washington, Chicago, New Orleans, Denver, San Francisco and Portland, Oregon. Experienced forecasters are placed in charge of the work for each district, and by means of this division of the work the forecasts are quickly made for the whole country and promptly distributed. The forecasts are telegraphed at Government expense to about 1,800 distributing stations, and from these points sent out by mail and telephone and given to the press. While nearly 100,000 addresses are served daily by mail, the most valuable distribution is by telephone and by the public press. More than 5,000,000 telephone subscribers are reached with great promptness, and practically every daily paper in the whole country publishes the forecast; a large proportion of them publish much other information relative to weather conditions.

A very efficient river service is maintained by the Bureau, covering all the important rivers of the country. Forecasts of river stages are made daily, and flood warnings issued when conditions call for such action. This problem has been very carefully studied, and the relation between the amount and character of rainfall over each drainage area, and the resultant rise of the stream, has been accurately determined. Flood warnings for the Mississippi River at New Orleans have on several occasions been issued from three weeks to a month in advance, giving the maximum height of flood for that point within three to four inches of the stage actually reached and within twenty-four hours of the time of its occurrence. This enabled the city to strengthen its levees, thereby protecting it from enormous damage and loss by flood. On the Ohio and many other rivers, on account of the greater fall in the stream, the warnings cannot be given as long a time in advance, but

nearly always from one to four or five days before the flood stage is reached.

Along the seacoasts and on the great lakes warnings of dangerous wind storms and hurricanes are given by means of signal flags by day and by signal lights by night. These warnings are also given to the naval and other wireless telegraph stations, and all vessels equipped with wireless telegraph outfits can get them on the great lakes and at sea when in working distance with the land stations.

Special warnings are issued during the winter season for cold waves which are expected to be severe enough to cause extensive damage. Also of heavy snows which might blockade railroad trains and street railways in the northern cities. This enables the management to get the snowplows ready and to take any other steps necessary to keep their lines open.

All these warnings and forecasts are based on the fact that general extensive storms have certain more or less regular paths of movement. With the exception of the West Indian storms, this movement is always easterly, that is, the storms move from the Pacific to the Atlantic. The storms may advance from the northwest to the southeast or from the southwest to the northeast, or between these two lines of progress, but in the United States storms always move in an easterly direction. The only exception to this rule is a class of storms originating east of the West Indies or in the Caribbean Sea, which generally move in a northwesterly direction until they reach latitudes 25° to 30° and then curve to the northeast, and eventually pass out over the Atlantic Ocean. As the wind blows in toward the center of a storm it is, generally speaking, preceded by an easterly wind and followed by a westerly wind. The forecaster, knowing these laws of storms, studies the chart prepared twice a day from the observations made at stations covering the whole country, notes the movement of any storm on it during the preceding twelve hours, and makes an estimate of what part of the country should be reached by it during the ensuing thirty-six hours, and makes his forecast accordingly. The principal difficulties encountered in this feature of the work are that the storm may increase or decrease greatly in strength or in speed of movement, but with long experience forecasters learn to judge very closely in these particulars.

It was evident that the opening of the Panama Canal would be followed by an enormous increase in the amount of shipping passing through the Gulf of Mexico and Caribbean Sea. In view of this fact the Chief of Bureau realized that steps should be taken to expand the

meteorological work over that region, so as to give protection to this great fleet coming from all quarters of the globe. These waters are subject, especially during certain seasons of the year, to violent hurricanes, and a relatively few stations had previously been maintained by the Bureau for a portion of the year in order to be able to give warnings to our southern coasts of the approach of hurricanes. With the opening of navigation through the Isthmian Canal the work of the Weather Bureau throughout the West Indies and the region of the Caribbean Sea will be extended and put upon an annual basis. At the present time the work in this region is limited in extent and maintained only during the summer hurricane season.

Another important feature of the Weather Bureau work is the establishment of precipitation and temperature records for the whole country. For this work more than 4,000 cooperative stations are maintained, covering the country between the regular stations. These stations are equipped with standard thermometers and shelter to secure their proper exposure, and with a standard raingauge. The observer is usually some resident of the locality, who, having an interest in scientific matters, does the work without compensation other than receiving the publications of the Bureau. These records are of great value to the many diversified interests. Engineers are almost dependent upon them in making plans for irrigation projects and water power and hydroelectric plants. In fact, hardly any industry, agricultural or horticultural enterprise can be intelligently established or carried on without a thorough knowledge of the climatic conditions which are to be experienced in the work. The direct management of this work is placed in the hands of a section director, each state usually constituting a section. This section director, who is the official in charge of one of the important regular stations in the state, issues the instruments to the cooperative observers, instructs them in their duties, and occasionally inspects the stations to make sure that the instruments are in good condition and properly exposed. The monthly records of these cooperative observers are forwarded to the section center, where they are carefully checked up to insure their accuracy, and then the information they contain is published in a printed report for the use of the public. During the crop growing season these cooperative observers send in weekly reports giving the weather conditions for the week and their effect on the various crops in their locality. A summary of these reports is telegraphed by the section director to the central office at Washington, where they are incorporated in the National Weekly

Weather Bulletin, published for the information of the public, during the summer season.

The Weather Service costs the Government a little over a million and a half dollars annually to maintain, but careful estimates show that it saves the country each year from losses of more than a hundred times this amount.

## THE DIESEL ENGINE

The Diesel engine has been characterized as the most revolutionary and important development in the field of motive power since the invention of the steam engine by Watt. Its vital importance lies not so much in the fact that it is capable of producing approximately twice as much energy as the steam engine can from the same amount of fuel, but more in the fact that it can be operated with tar and tar oils, derived from coal by coking, and produce more energy than if the coal had been burned under the boiler of a steam engine. In short, after the coal has been coked and the gas, coke, and finer by-products have been removed, the tar and tar oils remaining, when used in a Diesel engine, will produce more energy than could have been secured from the coal itself if used in a steam engine. The Diesel engine, briefly, is an internal combustion engine which uses highly heated, compressed air for ignition, instead of the electric spark, as in the ordinary gasoline engine. The piston, on the down stroke, draws in the ordinary air and on the up stroke compresses this air, against the cylinder head, under a pressure of 500 pounds to the square inch. Air under such pressure acquires a temperature of over 1,000 degrees Fahrenheit and when the air is hottest a jet of finely atomized oil is forced into the cylinder. The oil is ignited and the explosion forces the piston back and the operation is repeated.

### By Dr. Rudolf Diesel

Since its first appearance about fourteen years ago, many thousands of Diesel engines have been installed in all kinds of factories in all industrial countries, and also in the remotest corners of the world; proof has thus been obtained that the motor, when properly installed,

is a reliable machine, whose operation is as satisfactory as the best of other types of engine, and, in general, simpler, owing to the absence of all auxiliary plant and because the fuel can be employed directly in the cylinder of the motor in its original natural condition, without any previous transformatory process.

In 1897, when after four years of difficult experimental work I completed the construction of the first commercially successful motor in the Augsburg Works, it was proclaimed by the numerous engineering and scientific committees and deputations from various countries, who tested the machine, that a higher heat efficiency was attained by it than with any other known heat engine. As a result of subsequent experience in practice, and the gradual improvement in the manufacture, still better results have been obtained, and at the present time the thermal efficiency the motor attains is up to about 48 per cent and the effective efficiency in some cases up to nearly 35 per cent.

Technical knowledge and science are always progressing, and in later days these figures will be even further improved, but in the present state of our knowledge a higher efficiency cannot be reached by any process for changing heat into work; a further advance seems only possible by a new process of conversion, with an essentially novel method of operation which we today cannot conceive.

Therefore the Diesel motor is the engine which develops power from the fuel directly in the cylinder without any previous transformatory process, and in as efficient a manner as, according to the present state of science, seems possible; it is therefore the simplest and at the same time the most economical power machine.

These two conditions explain its success, which lies in the novel principle of its method of operation and not in constructional improvements or alterations to earlier engine types. Naturally the questions of construction, and the careful design of the details, are of considerable moment in a Diesel motor as in every engine; but they are not the cause of the great importance of this motor in the world's industry.

A further reason for this importance lies in the fact that the Diesel engine has destroyed the monopoly of coal, and has in the most general way solved the problem of the employment of liquid fuel for motive purposes. The Diesel motor has thus become, in relation to liquid fuel, what the steam and gas engine are to coal, but in a simpler and more economical manner; it has by this means doubled the resources of man in the sphere of power development, and found employment for a product of nature which previously lay idle.

In consequence thereof the Diesel motor has had a far-reaching effect in the liquid fuel industry, which is now progressing in a way that could not previously be anticipated. I cannot here enlarge on this point, but it may in general be said that owing to the interest which the petroleum producers have taken in this important matter new wells are being constantly opened out, and fresh developments inaugurated, and that from the latest geological researches it has been shown that there is probably as much, and perhaps more, liquid fuel than coal in the earth and, moreover, in much more favorable and more widely distributed geographical positions.

That the undertakings dependent on the petroleum industry have been equally strongly influenced is shown by the marked development which in quite recent times has occurred in the oil transport trade, especially the great development in the number of tank vessels which themselves use the Diesel motor for propulsion.

But the influence of the Diesel engine on the world's industry does not end here. Already in the year 1899 I employed in my motor the by-products from the distillation of coal, and the manufacture of coke—tar or creosote oil—with the same success as with natural liquid fuel. The quality of these oils was, however, generally unsatisfactory for use in Diesel motors and subject to continual variations. Only recently the interested chemical industries have succeeded in getting the necessary quality, and today this product enters definitely into the sphere of influence of the Diesel motor.

It follows, therefore, that this engine has an important influence on the two further industries—gas and coke manufacture—from which the by-products have now become so important that a great movement is beginning in connection with this question. It is impossible to further discuss this matter here, but one fact arises distinctly from this movement, namely, that the coal which appeared to be threatened by the competition of liquid fuels will, on the contrary, enter into a new and better era of utilization through the Diesel motor. Since tar oil can be employed three to five times more efficiently in the Diesel motor than coal in the steam engine, it follows that coal can be much more economically utilized when it is not burnt barbarously under boilers, or grates, but converted into coke and tar by distillation. The coke is then employed in metallurgical work and for all heating purposes; the valuable products from the tar must be extracted and used in the chemical industries, while the tar oil, and its combustible derivatives,

and under certain circumstances the tar itself, can be put to exceptionally favorable use in Diesel motors.

It is, therefore, of the greatest interest to employ the largest possible amount of coal in this refined and more economical manner, and thus both coal mining and the related chemical industry come within the influence of the Diesel motor, which is not inimical, but most helpful, to the development of the coal industry. The proper evolution of the fuel question which has already begun and is now progressing rapidly is as follows: On the one side use liquid fuel in Diesel motors, on the other side, gas fuel, also in the form of coke, in gas motors; solid fuel should not be employed at all for power production, but only in the refined form of coke for all other uses of heat in metallurgy and heating. The liquid fuels already mentioned by no means exhaust the list of fuel which may be used for Diesel motors.

It is well known that lignite, whose production is about 10 per cent of that of coal, leaves tar on dry distillation, which, when worked for pure paraffin, leaves as a by-product the so-called paraffin oil. Not all kinds of lignite are suitable for this purpose; nevertheless, so much of this oil is produced that up to now it has supplied, for instance in Germany, a very large proportion of the demand for liquid fuel for Diesel motors. Further, there are to be considered other products available in smaller but noteworthy quantities, such as shale oil, etc.; certain countries, as for instance France and Scotland, have large quantities of them and they are in use in many Diesel engine installations.

But it is not generally known that it is possible to use animal and vegetable oils direct in Diesel motors. In 1900 a small Diesel engine was exhibited at the Paris exhibition by the Otto Company, which, on the suggestion of the French Government, was run on Arachide oil, and operated so well that very few people were aware of the fact. The motor was built for ordinary oils, and without any modification was run on vegetable oil. I have recently repeated these experiments on a large scale with full success and entire confirmation of the results formerly obtained. The French Government had in mind the utilization of the large quantities of arachide, or ground nuts, available in the African colonies and easy to cultivate, for, by this means, the colonies can be provided with power and industries without the necessity of importing coal or liquid fuel.

Similar experiments have also been made in St. Petersburg with

castor oil with equal success. Even animal oils, such as fish oil, have been tried with perfect success.

If at present the applicability of vegetable and animal oils to Diesel motors seems insignificant, it may develop in the course of time to reach an importance equal to that of natural liquid fuels and tar oil. Twelve years ago we were no more advanced with the tar oils than today is the case with the vegetable oils; and how important have they now become!

We cannot predict at present the role which these oils will have to play in the colonies in days to come. However, they give the certainty that motive power can be produced by the agricultural transformation of the heat of the sun, even when our total natural store of solid and liquid fuel will be exhausted.

Finally, a few words on the manufacturing: The Diesel motor must be constructed with extreme care, and the best materials employed in order that it may properly fulfill all its capabilities; only the best and most completely equipped works can build it. Fourteen years ago there were very few factories which were able to undertake its construction, and it may be said that through the Diesel engine the manufacture of large machines has been raised to a higher level, in the same way as the manufacture of small machines has been brought on new lines by the automobile engine.

The Diesel motor is therefore not a cheap engine, and I would add a warning that the attempt should never be made to try to build it cheaply, by unfinished workmanship, particularly for export.

These fundamental conditions regarding the construction of the Diesel engine are no disadvantage, as has been frequently proved; on the contrary, they are precisely the reason of its strong position and form a guarantee of its worth.

DIESEL.

Munich, December, 1911.

# CHRISTIAN SCIENCE

## THE CONTRIBUTION OF CHRISTIAN SCIENCE TO THE WORLD'S THOUGHT

PREPARED BY W. D. MCCRACKEN, M. A., UNDER THE DIRECTION OF THE BOARD OF TRUSTEES UNDER THE WILL OF MARY BAKER EDDY

Christian Science is supplying the world with a demonstrable religion. It is proving by actual works the scientific nature of true Christianity. It is calling upon Christendom to revise its false notions about the Supreme Being, about man and the universe, and to establish its theology, medicine and science upon spiritual understanding instead of material belief.

In the opening words of the Preface to the Christian Science text-book, "Science and Health, with Key to the Scriptures," by Mary Baker Eddy, we read: "The time for thinkers has come. Truth, independent of doctrines and time-honored systems, knocks at the portal of humanity. Contentment with the past and the cold conventionality of materialism are crumbling away."

Christian Science represents a revival of primitive Christianity under modern conditions, whereby all of man's needs, mental, moral and physical, can be supplied by spiritual means, by the prayer of faith or understanding which James assures mankind shall not only save the sinner, but also the sick. Concerning prayer we read in Science and Health: "The prayer that reforms the sinner and heals the sick is an absolute faith that all things are possible to God—a spiritual understanding of Him, an unselfish love." (p. 1.)

Christian Science has effected the reconciliation between science and religion, showing that science, to be worthy of its name, cannot content itself with ascertaining only effects or phenomena, but must also enter into the explanation of the first cause or noumenon; likewise showing that true religion cannot be a matter of mere blind belief or sentiment, but of exact knowledge or science. Christian Science has contributed to the world's thought the spiritual or metaphysical interpretation of the Bible which makes that book available for the solution of everyday problems.

In theology Christian Science is correcting common misconceptions about God and man's essential nature. Science and Health defines God in the following terms: "God is incorporeal, divine, supreme, infinite Mind, Spirit, Soul, Principle, Life, Truth, Love." (p. 465.) Concerning man we read in the same work: "Man is not matter; he is not made up of brain, blood, bones, and other material elements. The Scriptures inform us that man is made in the image and likeness of God. Matter is not that likeness. The likeness of Spirit cannot be so unlike Spirit. Man is spiritual and perfect." (p. 475.) Christian Science overturns the false supposition that God is the author of evil as well as of good, by showing that God, as Truth, cannot produce evil which is error. It likewise proves by its practice that the real man is not material nor the victim of so-called material conditions.

Christian Science teaches that, contrary to common opinion, substance is invisible, and matter substanceless. "Substance," we read in Science and Health (p. 468), "is that which is eternal and incapable of discord and decay. Truth, Life, and Love are substance, as the Scriptures use this word in Hebrews: 'The substance of things hoped for, the evidence of things not seen.'" "Matter," on the other hand, Mrs. Eddy defines as "an error of statement" (ibid., p. 277); and also states, "Matter disappears under the microscope of Spirit" (ibid., p. 264).

In the realm of medicine Christian Science teaches that the divine Mind is the natural and normal healer and discards matter or mesmerism as healing agents: "If Mind was first and self-existent, then Mind, not matter, must have been the first medicine" (ibid., p. 142). In drawing a sharp distinction between the operation of this Mind and the seeming effects of human will-power, variously designated as animal magnetism, mesmerism, hypnotism, etc., Mrs. Eddy writes: "The author's own observations of the workings of animal magnetism convince her that it is not a remedial agent." * * * "In no instance is the effect of animal magnetism, recently called hypnotism, other than the effect of illusion" (ibid., p. 101).

The healing of disease by Christian Science is an after effect, a necessary consequence of the transformation of the human mind through the divine Mind or Principle. On this point the Christian Science textbook states: "The physical healing of Christian Science results now, as in Jesus' time, from the operation of divine Principle, before which sin and disease lose their reality in human consciousness and disappear as naturally and as necessarily as darkness gives place

to light and sin to reformation" (ibid., Pref. xi). It should, however, be clearly understood that this physical healing is not the main purpose of Christian Science. Although it may have attracted more public attention than any other of the redemptive activities of Christian Science, Mrs. Eddy writes explicitly concerning physical healing in her work, "Rudimental Divine Science" (p. 2): "It is only the bugle-call to thought and action, in the higher range of infinite goodness. The emphatic purpose of Christian Science is the healing of sin. * * *"

To those looking with hope and faith towards reformation and cure Christian Science presents itself as the guide leading to happiness, health and holiness. During more than forty years of practice the correctness of its teaching has been demonstrated by a growing multitude in all quarters of the globe. Mrs. Eddy, its Discoverer and Founder, thus describes the two-fold nature implied by its name, as meaning both science and application: "The term Christian Science was introduced by the author to designate the scientific system of divine healing. The revelation consists of two parts: 1. The discovery of this divine Science of Mind-healing, through a spiritual sense of the Scriptures and through the teaching of the Comforter, as promised by the Master. 2. The proof, by present demonstration, that the so-called miracles of Jesus did not specially belong to a dispensation now ended, but that they illustrate an ever-operative divine Principle" (Science and Health, p. 123).

Therefore the practice and proof of Christian Science cannot be divorced from its teachings, for it is not merely doctrinal or creedal, but scientific and of instant availability in the hour of need.

W. D. McCRACKAN.

# OSTEOPATHY

## HOW I CAME TO ORIGINATE OSTEOPATHY

By Andrew T. Still

My first awakening to the principles which today have culminated in the science called "Osteopathy" was made when I was about ten years old. I was a boy on my father's farm in Macon county, Missouri. I was subject to sick headaches, and while suffering from one of these attacks one day I was instinctively led to make a swing of my father's plowline between two trees. My head hurt too much to make swinging comfortable. I let the line down to within eight or ten inches of the ground, threw the end of a blanket on it, and lay down on the ground, using the lines for a swinging pillow. To my surprise I soon began to feel easier and went to sleep. In a little while I got up with headache and fever gone. This discovery interested me and after that, whenever I felt my headache spells coming on, I would "swing my neck," as I called it.

The next incident which gave me cause for thought occurred when I contracted dysentery, or flux, with copious discharges mixed with blood. There were chilly sensations, high fever, backache and cold abdomen. It seemed to me my back would break, the misery was so great. A log was lying in my father's yard. In the effort to get comfort I threw myself across it on the small of my back and made a few twisting motions, which probably restored the misplaced bones to their normal position, for soon the pain began to leave, my abdomen began to get warm, the chilly sensation disappeared, and that was the last of the flux.

### MILL MACHINERY AROUSED MY INTEREST IN HUMAN MACHINERY

My father, as a pioneer, was a farmer, a mill owner, a minister and a doctor. I studied and practiced medicine with him.

Pioneer life on a western farm in those days was one in which all the inventive powers one might possess were given ample chance to

show forth. Nearly all the farm machinery had to be made by hand and on the farm. There was very little to buy and less money to buy it with. My father had a grist and saw mill run by water, in the working of which I became very much interested. Later, I bought an interest in a steam saw mill, and took a course of instruction in milling machinery for practical purposes.

As I studied this mill machinery I got my first clear idea of the machinery of the human being. My mind invariably associated and compared the machinery of the mill with the machinery of the human being: with the drive-wheels, pinions, cups, arms and shafts of the human, with their forces and supplies, framework, attachment by ligament and muscle, the nerve and blood supply. "How" and "where" the motor nerves receive their power and motion, how the sensory and nutrient nerves act in their functions, their source of supply, their work done in health, in the parts obstructed, parts and principles through which they passed to perform their duties of life — all this study in human mechanics awoke with new vigor within me. I believed that something abnormal could be found which, by tolerating a temporary or permanent suspension of the blood in arteries or veins, would produce the effect which was called disease.

With this thought in mind came such questions as: What is disease? What is fever? Is fever an effect, or is it a being as is commonly described by medical authors? I took disease to be an effect, experimenting and proving the position, being sustained each time by Nature's response in the affirmative.

Early in the '60s I took a course of instruction in the Kansas City School of Physicians and Surgeons, studying such branches as were taught in the medical schools of that day. I took up the regular practice of an allopathic physician. I was called a good doctor.

### "THE PROPER STUDY OF MANKIND IS MAN"

During all this time I had devoted a large part of my time to the study of anatomy, which attracted me strongly. I read every book on the subject I could get hold of, but my chief source of study was the book of Nature. I found myself more and more believing that "the proper study of mankind is man," and the best method to pursue it is to dissect and study the body itself. The skinning of wild animals in my youth brought me into contact with muscles, nerves and veins.

The skeletons of the Indians were my next study in bones, and

I went on making numberless experiments with bones until I became very familiar with the entire bony structure of the human body. Finally, I tried an experiment of my own: I made a picture or chart of the bones of the whole body, then stood blindfolded, or with my back to a table. A bone would be handed to me by an assistant. I would take it in my hands and by the "feel" of it would name it and direct where it should be placed on the chart (right or left). I carried this to the extent of even the smallest bones of the hands and feet, and those of the spine, until the chart was filled in complete. This I used to do over and over again. For not less than twelve months I studied bones alone, before taking up descriptive anatomy, because I wanted to know what a bone is and its use. I became as familiar with every bone as I was with the words "father" and "mother." Of course, all this meant untiring work, and I have hardly expected my students to follow me over the entire length of this portion of my road. Nevertheless, I believe as strongly today as ever that the closer they follow this road, the better for their patients. They must study and know the exact construction of the human body, the exact location of every bone, nerve, fibre, muscle and organ; the origin, the course and flow of all the fluids of the body, the relation of each to the other and the function it is to perform in perpetuating life and health. In addition, they must have ability to enable them to detect the exact location of any and all obstructions to the regular movements of this grand machinery of life, and supplement this ability with skill to remove all such obstructions.

From this study in bones I went on to the study of muscles, ligaments, tissues, arteries, veins, lymphatics and nerves.

I began now to feel that I was irresistibly headed for some road: what road I myself knew not. Of one thing I was certain: I was getting farther away from the use of medicines in the treatment of ills and ails. I was a physician of the old school in name but not in fact.

I carried on my theories; I practiced them wherever I could find people who would place confidence in me, until the Civil War came on. Then I enlisted and went "to the front."

On resuming my duties as a private citizen after the war, I took up again the study and research of my all-absorbing topic—how to cure disease without medicine—and on June 22, 1874, there came into my mind the first clear conception of the practical workings of what is now known as the Science of Osteopathy. This day I celebrate as its birthday.

### ONE OF THE FIRST CASES I TREATED

In the autumn of 1874 I was given a chance to try my ideas on a case of flux. I was walking with a friend on the streets of Macon, Missouri, in which town I was visiting, when I noticed in advance of us a woman with three children. I called my friend's attention to fresh blood that had dripped along the street for perhaps fifty yards. We caught up with the group and discovered that the woman's little boy, about four years old, was sick. He had only a calico dress on, and to my wonder and surprise his legs and feet were covered with blood. A glance was enough to show that the mother was poor. We immediately offered our services to help the boy home. I picked him up and placed my hand on the small of his back. I found it hot, while the abdomen was cold. The neck and the back of the head were also very warm and the face and nose were cold. This set me to reasoning, for up to that time the most I knew of flux was that it was fatal in a great many cases. I had never before asked myself the question: What is flux? I began to reason about the spinal cord which gives off its motor nerves to the front of the body, its sensory to the back; but that gave no clew to flux. Beginning at the base of the child's brain, I found rigid and loose places in the muscles and ligaments of the whole spine, while the lumbar portion was very much congested and rigid. The thought came to me, like a flash, that there might be a strain or some partial dislocation of the bones of the spine or ribs, and that by pressure I could push some of the hot to the cold place, and by so doing adjust the bones and set free the nerve and blood supply to the bowels. On this basis of reasoning I treated the child's spine, and told the mother to report the next day. She came the next morning with the news that her child was well.

There were many cases of flux in the town at that time and shortly after, and the mother telling of my cure of the child brought a number of cases to me. I cured them all by my own method and without drugs. These began to stir up comment, and I soon found myself the object of curiosity and criticism.

### WHEN I STARTED THE AMERICAN SCHOOL OF OSTEOPATHY

Another case which I was asked to see brought upon me still further criticism. A young woman was suffering with nervous prostration. All hope had been given up by the doctors, and the family

was so told. After a number of medical councils her father came to me and said: "The doctors say my daughter cannot live. Will you step in and look at her?" I found the young woman in bed, and from the twisted manner in which her head lay I suspected a partial dislocation of the neck. On examination I found this to be true—one of the upper bones of her neck was slipped to one side, shutting off, by pressure, the vertebral artery on its way to supply the brain. In four hours after I had carefully adjusted the bones of her neck she was up and out of bed.

I went through those interesting yet trying days deaf to criticism and comment. I worked alone, studying, investigating, experimenting.

Gradually people began coming to me in increasing numbers, and soon I found that my practice was beginning to grow beyond the limits of my strength. Several persons, seeing my increasing practice, now began to urge me to teach them a knowledge of the practical workings of my discovery. In the early '90s I concluded to teach others the principles that underlay my drugless work. I realized that I must have help or break down. I had four sons and one daughter, able-bodied young people, and the thought came to me to educate them in this science in order that they could assist me in my work.

I employed the best talent that I could find to teach them anatomy, physiology and chemistry, teaching them, myself, the principles and practice of my own science. After my school had been in running order a short time others became interested and asked permission to join, and the class increased in numbers. At the end of the first year I had some students who were able to help me in a way, and in the course of two years I really had assistance. This was the origin of what is known today as the American School of Osteopathy.

With the origination of the school came, of course, the necessity of a name to designate the science, and I chose "Osteopathy." I reasoned that the bone, *"osteon,"* was the starting point from which I was to ascertain the cause of pathological conditions, and I combined the "osteo" with "pathy."

So "Osteopathy," sketched briefly, was launched upon the world.

### NOW WHAT, REALLY, IS OSTEOPATHY?

Many people naturally ask: What is Osteopathy?

Osteopathy is simply this. The law of human life is absolute, and I believe that God has placed the remedy for every disease within

the material house in which the spirit of life dwells. I believe that the Maker of man has deposited in some part or throughout the whole system of the human body, drugs in abundance to cure all infirmities: that all the remedies necessary to health are compounded within the human body. They can be administered by adjusting the body in such manner that the remedies may naturally associate themselves together. And I have never failed to find all these remedies. At times some seemed to be out of reach, but by a close study I always found them. So I hold that man should study and use only the drugs that are found in his own drugstore—that is, in his own body.

I do not believe, and I say this only after forty years of close observation and experiments, that there are such diseases as fever—typhoid, typhus or lung—rheumatism, sciatica, gout, colic, liver disease, croup, or any of the present so-called diseases. They do not exist as diseases. I hold that, separate or combined, they are only effects of cause, and that, in each case, the cause can be found and does exist in the limited or excited action of the nerves which control the fluids of a part of or of the entire body. My position is that the living blood swarms with health corpuscles which are carried to all parts of the body.

Osteopathy is, then, a science built upon this principle: that man is a machine, needing, when diseased, an expert mechanical engineer to adjust its machinery. It stands for the labor, both mental and physical, of the engineer, or Osteopath, who comes to correct the abnormal conditions of the human body and restore them to the normal. Of course, "normal" does not simply mean a readjustment of bones to a normal position in order that muscles and ligaments may with freedom play in their allotted places. Beyond all this lies the still greater question to be solved: How and when to apply the touch which sets free the chemicals of life as Nature designs.

Osteopathy to me has but one meaning, and that is, that the plan and specification by which man is constructed and designed shows absolute perfection in all its parts and principles. When a competent anatomist (as the successful Osteopath must be), in treating the human body, follows this plan and specification, the result will be a restoration of physiological functioning from disease to health.

An Osteopath is only a human engineer who should understand all the laws governing the human engine and thereby master disease.

Osteopathy absolutely differs from massage. The definition of "massage" is *masso,* to knead: Shampooing of the body by special

manipulations, such as kneading, tapping, stroking, etc. The masseur rubs and kneads the muscles to increase the circulation. The Osteopath never rubs. He takes off any pressure on blood vessels or nerves by the adjustment of any displacement, whether it be of a bone, cartilage, ligament, tendon, muscle, or even of the fascia which enfolds all structures; also by relaxing any contracture of muscle or ligament due to displacements, to drafts causing colds, to overwork or nerve exhaustion. The Osteopath knows the various nerve centers and how to treat them, in order that vasomotor nerves can act upon the blood vessels, bringing about in a physiological manner a normal heart action and freeing up the channels to and from the heart. The Osteopath deals always with causes, has no "rules of action," as such, but applies reason to each case according to the conditions presented, treating no two cases quite alike. He knows from past experiences that the effect seen is produced by a cause with which he must deal in order to give relief.

The Osteopath is a physician. The masseur does not take the responsibility of the full charge of a diseased condition, but works under the direction of a physician, and has to do with effects, applying by rote to the body so much rubbing, so much stroking, so much tapping, so much kneading, etc., there being definite rules laid down applicable to general cases.

Osteopathy is a science and an art also. It includes a knowledge of anatomy, biology, physiology, psychology, chemistry and pathology. Its therapeutics are independent and original, and as extensive as the entire medical and surgical fields.

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# ARCHÆOLOGY

The Beginning of Archaeology may be said to have been made with the decipherment of the Rosetta stone. This was found at Rosetta in 1799. It contained three inscriptions, one in hieroglyphic, one in demotic and the other in Greek. There was reason to suspect that the three inscriptions were identical in meaning and with this clue scholars set to work to decipher the hitherto unknown hieroglyphics. Young and Gell made a good beginning and by 1832 Champollion had succeeded in deciphering all the inscriptions.

Before this result had been reached Grotefend made a substantial start at explaining the cuneiform characters of Mesopotamia by comparing the known names of Persian kings with cuneiform inscriptions he thought might contain the names. This gave the key, and Bournouf and Lassen (1836-1844) completed the short Persian alphabet. Next Rawlinson, from the trilingual inscription at Behiston in Persian, Assyrian, and Vannic worked out the great Assyrian syllable-system of six hundred signs.

Since this time Egypt and Mesopotamia have furnished magnificent fields for research into times hitherto lost below the horizon of history, and the date of the beginnings of civilization has been placed further and further back.

The relics of the Egyptian literature hidden in papyrus rolls belonging to the period from A. D. to 1000 B. C. have been deciphered. The Book of the Dead, showing the worship of Osiris, (see volume I) is one of the great finds of this period. Study of the remains of temples, tombs and towns has shown before this period and from 1000 to 1600

B. C. the everyday life of a great empire. Anterior to this had come the invasion of the Hyksos; prior to the Hyksos the civilization of the twelfth dynasty (about 2600 B. C.); then back beyond a period of decay, the civilization of the Old Kingdom (4500-3500 B. C.) that built the grandest of the pyramids and monumental remains. This was preceded by the invasion of a people probably from the direction of the Red Sea (about 5000 B. C.), who brought with them much of the base of the civilization of the Old Kingdom; and dating probably from as early as 6000-5000 B. C. are found relics of a primitive Egyptian race that built towns of brick, used linen, leather, pottery, wood, ivory, copper, and polished flint.

The remains in Chaldea seem to be even more ancient. The religious literature given in the first volume dates further back than any literature of Egypt. Libraries of clay tablets seem to have been in existence before 3000 B. C. Researches have not been as extensive in the sites of towns as in Egypt and the oldest civilization is not as well known. We give below a summary of the facts of the Babylonian period.

In Greece, archæology has discovered the remains of high civilizations existing in the Mycenian age before the Doric invasion of about 1000 B. C. The earliest relics of civilization seem to go back to about 3000 B. C.

But archæology pushes its researches into the study of primitive man far back before the eras of even Chaldea or Egypt. The great ages of these countries correspond to the ages when men used bronze largely for weapons and ornaments (about 3000-1000 B. C.) and even to the age of copper (5000-3000 B. C.). The lake dwellers belonged to the latter period or even before. Prior to them there were workers in polished stone. The ages of the cave dwellers, who at the last were workers in bone, and at the first were rude shapers of stone, carry us back no man knows how many thousand or tens of thousand years.

CUNEIFORM INSCRIPTION ON CLAY TABLETS

# F. E. PEISER

## A SKETCH OF BABYLONIAN SOCIETY

THE PREPARATION of a history of Babylonian culture is surrounded with so many difficulties that only those but slightly acquainted with its aspects would dare to undertake the task. In fact, the most necessary preliminary studies have been begun only within the last few years. Historical works on the subject show a disregard or ignorance of the elements of the history of culture, while the preliminary works which have appeared lack more or less the bond of interrelationship. It is, therefore, not an unimportant work to give for a part of the history of culture an outline, or skeleton, about which the scattered and disconnected studies, thus far attempted, may rally, and thus make it possible to proceed more methodically in the consideration of individual questions.

For these reasons I have decided to condense several lectures written some years ago into the present publication, which neither claims completeness nor to pronounce the final word. On the contrary, I hope that sharp criticism will be aroused by this sketch, through which the common aim or object may be advanced. As this is really a sketch of the subject, I have refrained from citing and collating authorities which are to find their place in monographs to follow; and this also explains why I have taken up society as a unit, and scarcely more than indicated its development. The work is based mainly upon the conditions of Babylon in the sixth and seventh centuries before the Christian era. In going still farther backward, the task is to unravel the close-meshed fabric of Babylonian culture and to study the history of its development along the individual strands.

In the activity of thousands of years the Euphrates and the Tigris have built up from alluvial drift the territory between their arms. Sand and stones, stripped by the melting snow from the Armenian Mountain peaks, have formed deposits which pushed the Persian Gulf ever farther back toward the south and east. Thus we have in the south

a province with no mountainous formations, but only plains and hills of sand, with but few stones. The plain is traversed by the two rivers named, which differ in relative level at two points; at one place the water of the Euphrates flows over and feeds the Tigris, while 100 miles southward an equalization occurs by the reflux of the Tigris into the Euphrates.

If we consider the climate of the country, we find in the south, in the whole of Babylonia, the characteristics of the hot desert climate modified only by the moisture from the rivers. The desert extends up along the Euphrates and spreads far away beyond it over to Mesopotamia. Nevertheless we must form no false picture of the Mesopotamian desert. After heavy rains it is overgrown by vegetation with wonderful rapidity; and the traveler from the Occident is often amazed when, after the rain, the entire desert appears yellow with crocus plants or blue with other growths. At such times the Arabian nomads cross the Euphrates to pasture their cattle, and thus thousands of years ago strife arose between the residents and the invaders, which continued yet further during the historical development.

So far as historical notices accessible up to this time extend, there still remains the sole probability that in the south of the country traversed by the two streams, northward, eastward, and westward from the Persian Gulf, originally dwelt people of a race who used an agglutinative language, were characterized by a compact bodily frame, and were of a Mongoloid type. I do not wish to enter deeply into several much too radical theories concerning the Sumerians and their racial affinities; I would merely like to refer to the fact that I have already in my book, Hittite Inscriptions, called attention to the possibility of a connection between the so-called Hittites, non-Aryan proto-Armenians, and Sumerians, and that the ancient population of Elam might easily be included with these. But even in the earliest times Semites appear to the north of the district bordering on the Persian Gulf. As in the historical development between 2000 and 600 B. C., two invasions and settlements of Semitic nomads can be recorded, in which connection the theory advanced by Winckler concerning the Aramæans and the Chaldeans is especially to be noticed, it is very natural to assume also for these most ancient Semites a nomadic period, which had already ended when history begins to raise the curtain before our searching eyes.

The political supremacy of these oldest Semites introduced racial variations. We may look upon the invading Kassites from the Kas-

sæan mountains as a third element, which also for a time furnished the acknowledged rulers of Babylonia. The second wave of Semitic immigration, the Aramaic tribes, had begun in the time of the Kassu rule, and for centuries furnished the nomadic population of the steppes, against whom the population of the cities were engaged in struggle. The advances of the tribes and the retreats of the agricultural population were accompanied by ruins of dikes and canals until a strong hand again forced the nomads back and restored the water courses. These tribes became gradually settled and constituted the fourth racial element, as appears from several historical notices and from Assyrian contracts.

Finally, we must notice the pushing forward of the Semitic Kaldi tribes from the south, and the contemporaneous efforts of the Assyrians from the north to obtain the supremacy in Babylonia. But while the preceding four elements composed the basis or foundation out of and upon which ruling classes developed, these two latter parties formed external factors which influenced the social and political life of Babylon.

If we also mention as a potent external factor the Elamite monarchy, which endeavored to play off the Kaldi and the Assyrians against each other in their struggle for Babylon, we have briefly sketched the picture of the inhabitants, their origin, and those of their neighbors who come into consideration.

From these elements and their sediment was formed what we are accustomed to regard as the Babylonian state. We must not imagine an oriental state, however, as being any such firmly welded whole as are our modern European states. Race feeling operated in a manner altogether different from among us. There the whole life of the State was concentrated about great cult centers. Surface configuration, intercourse relations, and the coincident power of single provinces welded a greater political unit about a cult center. Thus was formed a political organization that perhaps soon after was merged into a larger unit, and left nothing but a name behind it in proof of its former existence. Among these political units we know of Sumer and Akkad, that is, the power once connected with Ur, the Kingdom of Babylon; also smaller ones in the north, such as the kingdom of "the four regions" and the Kingdom of Kisshat, of which the cult center is not yet precisely determined, but probably to be sought in northern Mesopotamia. Farther away from the proper center lies Elam, which had attained the rank of a State since primeval times. We see Assyria and farther to the north, the proto-Armenian tribes.

The political history of Babylon, even in the earliest times, presents an alternating picture of centralization and disintegration of the empires embodying the centralization. The question presents itself, what could have been the cause which in so remote a period again and again led to the consolidation of a great district, while as yet, in all neighboring provinces, with few exceptions, only a more or less feeble tribal bond could be formed. The answer may be inferred from the following circumstances:

(1) As soon as an individual by reason of the domination of one of the smaller commonwealths had succeeded in restoring the centralization after a period of its decay, his main efforts were especially directed toward the restoration of the neglected canals.

(2) During a decline of the central authority the canals became choked with sand.

(3) The Babylonians imagined the period of such political weakness to be a time of anger of the gods, who were deserting the country and giving the supremacy over to its enemies.

(4) The hydrographic conditions of the country of the two rivers were of such nature as in themselves to call for regulation and utilization. For, while the bed of the Tigris in its northern portion is lower than the Euphrates, so that the latter seeks an outlet toward the former during inundations, farther on, at the second confluence of the rivers, it is higher. This peculiarity, which apparently contradicts the fact that the Tigris in that part flows much more swiftly than the Euphrates, is explained by the fact that the former flows in a straight course, and thus has a much shorter distance to traverse than the Euphrates, which describes a large loop. And while the swifter course of the Tigris prevents it from choking its channel, the Euphrates at once covers its domain, its bed, and channels with its alluvial drift whenever a systematic regulation is not kept in continuous operation. It repeatedly fills its own channel, tears away the banks, and reduces the painfully acquired agricultural land to swamp and waste again.

In reply, then, to the inquiry as to the cause of this ever-reappearing centralization, it may be answered that the nomads who first settled in the country of the two rivers were compelled by the hydrographic conditions to regulate the river system; this regulation demanded and developed an administrative center; these conditions gave as a result the idea that the country belonged to the gods; and this idea had force to bring about a real centralization. Ideas continue in activity thousands of years after the conditions out of which they arose have altered. We must not be surprised, therefore, at finding this idea operative under later conditions; we may even use it as a clue to the complicated life of New Babylon.

If, now, we consider the State—I speak, of course, of the individual States in their inward and outward design—we have to regard two

factors: (1) The State centers about one focus of cult. For the Orient this cult center is of the greatest importance, since the development of the State is most closely connected with it. (2) The other point of view is the political-economic. The citizens of each one of these States became landowners soon after they had settled in Mesopotamia. They did not cultivate the land themselves, however, but the work was done by serfs or semi-serfs, obtained by military expeditions and by purchase. We have private contracts from which we see how boat expeditions were undertaken up the Euphrates against the northern provinces, where the less civilized tribes lived, and in which the contractors, who in this case were merchants and freebooters, undertook to procure slaves.

Among the Assyrians, in contrast to Babylonia, the idea of the State was one of somewhat firmer consolidation. This was caused by the situation of Assyria, wedged between Babylonia and northern Mesopotamia, and by the institution of a mercenary army since Tiglath-Pileser I, which was likewise an efficient factor in the formation of a stronger government than in Babylonia. Nevertheless, the political institutions of the two States are somewhat similar.

The officials were grouped in three orders—those who were occupied with the internal administration; those who watched over the neighboring and tributary States, and the military service that guarded the interests of the State against enemies, and were frequently employed as governors of subjugated States and tribes. The old nobility had, moreover, a direct interest in the State, inasmuch as they pre-eminently shared the offices among themselves.

The remaining subjects of the king were partly direct and partly indirect, and the latter certainly, in so far as they were, first of all, subordinate to the hierarchy of a temple.

The interest that the individual citizens had in the State lay, apart from the especial interests of the nobles, in the defense against outward attack and in the maintenance of law and justice; and we find, in fact, that the Babylonian State was characterized by a highly developed juridical life. As against the nomadic tribes the domestic militia and the mercenaries had to suffice more or less, while against the neighboring powers the tribes themselves were now and again impressed into service.

Of the constitution of the Babylonian State we know very little indeed, and the little we do know is of a negative character, only as the documents give us information of the abrogation of this or that privilege, etc. Besides that, there are preserved to us several charters from Babylonian provinces, which grant certain prerogatives to one family or

another. Thus it was legally established that officials of the State should not enter a free territory of this kind; that its inhabitants should not be arrested by the State police nor be constrained to the performance of a number of various villein services owed to the State. We may probably assume that certain cities obtained charters or franchises, but we have only proofs for the investure of foreigners with civic rights first in the time of the Persians, when very soon resounds the cry *"Civis Susanus sum"* (I am a citizen of Susa), which is important for our appreciation of Cyrus's statesmanship.

From all accounts we must conclude that the Babylonian kingdom was divided into provinces, which were subdivided into administrative districts, within which lay the free family estates. Everywhere but in the free estates or territories the central authority had the right to command arrests, to construct roads, bridges, etc., and to collect stallions for the breeding studs of the government, or to make arrangements for the maintenance of the studs. The contrast thus made apparent between the rights of the general government and those of the free estates indicates a period of transition from the feudal to the centralized system. The former is, of course, the earlier and bears witness to a time when the families were absolutely independent. With the growth of the central power, however, the importance and influence of the old families diminished, and only now and then occurred a relapse into the feudal system, such as, for instance, we learn from the charters. Such privileged territories were generally held in the possession of the old noble families. These also furnished the State with the entire force of its dignitaries, and the high political offices very often descended from father to son.

The citizens were, indeed, as explained above, very different as regards race and legal status, but soon became amalgamated under the influence of the higher civilization.

The Babylonians appear to us enterprising and rather vindictive and litigious, as shown by the numerous lawsuits. In their relations with the gods they assumed the position of equals, and yet at the same time displayed the deepest submission. They made offerings to the gods, but also demanded favors in return. If a person had once committed an offense, however, he could not lament sufficiently before the higher powers.

The family formed the focus of the whole life of the Babylonians, and presented a united and unbroken front. Thus we often find the interests of the State and those of the family in conflict. The sharp sep-

aration of the families from one another is easily explained by the former nomadic life of these peoples.

Since, moreover, the individuals of a clan were dependent upon one another, the legal conception was gradually developed that the property of an individual belonged not to himself, but to his whole family. We may thus explain the fact that real estate could be sold only on condition that the other members of the family gave their assent or signified their willingness by their presence while the bill of sale was being drawn up. A further important factor in the development of the family life is ancestor worship and the conceptions resulting from it, which have had the greatest influence in the religious development of the Semites.

The families are, then, as we have seen, the actual units out of which the State is composed. The individual members of the family stand, therefore, in a somewhat freer position as regards the State; they feel that they are first of all members of their own family, from which their connection with the State results secondarily.

The relation of the king to the subject was a double one. (1) The king was the highest representative of the family, which implies the conception of the whole State as one family. Under this conception he was the representative of his subjects in their relations with the gods, and had as such a great authority. (2) The king, however, did not belong to the particular families to which the individual subjects belonged. Therefore family interests in this regard often overbalanced the duty owed to the king.

The individual families in Babylon were often at enmity with one another, and this antagonism had close relations with external politics. All the powers round about Babylon, as the Elamites, Assyrians, and Kaldi, had their partisans in the city. The partisans, however, belonged respectively to the different families. According as the influence of this or that external power predominated in Babylon, one family was played off against another, and their relative possessions were thus shifted accordingly. The two boundary stones belonging to this period—one dated from Sargon, the other from Merodach-Baladan—are very good illustrations of this condition.

The relation of children to their parents was at first a rather patriarchal one, traces of which are found down to the latest times. We have a document from which appears the father's right of protest on the occasion of his son's intended marriage. The son might, indeed, marry against his father's will, but in that case the marriage was not

of full validity. On the other hand, we find phenomena which result from the further development of the family under the influence of privatt property rights. Documents dated from about 2300 B. C. refer to adoption to gain laborers. Another kind of adoption was one for the purpose of the fulfillment of obligations imposed by ancestor worship; that is to say, if there were no sons, a slave might be adopted, who should, after the father's death, bring him the customary offerings. We often see that elderly Babylonians intrusted themselves to a child or adopted slave for care and shelter, and made over their property to the child on condition of being supported by him. This custom is to be regarded already as a result of the evolution from collective to individual property rights.

We do not know much about Babylonian education. We can only draw inferences from what Assurbanipal relates concerning his education in the *bit riduti* (nursery). He states that he was trained in feats of bodily dexterity, and in reading and writing as well. We may probably assume that the well-to-do families had their children taught in a writing school (*bit dupsaruti*). We have fragments of tablets in which mention is made of a writing house, and there are still extant copies of historical and epic works prepared by writing pupils and then presented to a library.

Trades were diligently practiced, and children and slaves were bound apprentices to master craftsmen. The period of apprenticeship lasted several months or several years, according to the difficulty of the trade. This may have been the case among business men as well, for we find slaves who carried on business for their masters. If the slave proved to be true and clever, he might even be manumitted, but he still retained a connection with the family. Although then, in this case, the idea of the family did not rest upon blood relationship, it nevertheless appeared strong in all directions.

If, now, we compare the inference from the particulars gathered concerning the family with that drawn from the inscriptions, it is shown that what is apparent from the documents was also legally established. For example, sons-in-law could pass over into the family of the wife and become legally associated to the ancestor worship of this family.

As regards the relation of the family to the temple, we must make a distinction between the oldest cults existing within the domains of the individual families and the cults of entire cities. No especial imposts were necessary for the former, since these cults were cared for solely by the members of the respective families. For the latter, on the con-

trary, special taxes were raised by the king. Occasionally, however, it happened, also, that the king assigned to a temple a whole family, who then had to provide for its maintenance. This probably occurred for the most part after insurrections had been quelled.

In the deportations so often practiced by the Assyrians, the question is always of the noble families, who were thereby placed in a trying situation. They might, indeed, carry on their religious observances even at their place of exile, but were yet obliged to feel themselves in banishment, since, according to its idea, ancestor worship was attached to the graves of their forefathers. Upon the latter point we have but little material; nevertheless, this much is evident from it—that it was not necessary that the graves should be separate. We find, on the contrary, in Babylonia, great sepulchers, whither the dead from whole districts were brought. These sepulchers were naturally the centers for the surrounding district, and individual families connected themselves, respectively, with such a temple and such a sepulcher. To understand the development of the family upon the religious basis of ancestor worship is extremely important in the historical consideration of the Semitic nations, and without this understanding a number of facts cannot be explained.

The attempt has been made to prove the existence of a matriarchate also among the Semites, and it has been thought possible to adduce evidence for this view from the oldest inscriptions. This theory depends upon the arrangement of the names of the gods and goddesses and of the ideograms for man and woman. Nevertheless, the fact that in the Sumerian texts the feminine element precedes the masculine is capable of explanation on othér grounds.

It appears, however, from the Old Babylonian documents that the wife could conclude independent private contracts; and that she had a legal standing in the family circle as well as before a court of law; that is, she was capable of being her own representative in regard to her own affairs. She had her private property and retained the right to dispose of it. Between the thirtieth and the twentieth centuries B. C. marriage had already developed in Babylonia upon the basis of individual property rights. Of course there existed at the same time remnants of more ancient modes of marriage, especially when the contracting parties were not of equal caste. Thus we have in the time of the New Babylonian Kingdom—that is, about the seventh century B. C. —a case where a man married a singer. In the marriage contract the death penalty was laid upon the eventual unfaithfulness of the wife; the

husband, on the other hand, could put his wife away forthwith on the payment to her of a specified sum of money. In ordinary cases the wife obtained her dowry back if she was repudiated. The children remained in the husband's family. There are, however, remnants of a system where, upon a separation, the daughters followed the mother. The material does not suffice to furnish answers to all questions relative to this subject.

We find women active in trade, industry, and agriculture, and although here, as elsewhere, men were in preponderance, we see them as priestesses in public worship. In the more ancient time they had not only the religious ceremonials to perform, but authority to manage the property of the deity. Women were also much esteemed as prophetesses. Thus there was in Arbela a temple which harbored a great number of prophetesses who were, for example, much consulted by Asarhaddon.

After all that I have said about the position of woman there is no occasion for surprise if we find her in an influential position as queen. An indication of this is the short notice in the synchronistic history that an Assyrian princess ascended the Babylonian throne, and, *vice versa,* we find in the ninth century the Babylonian princess Samurammat upon the Assyrian throne. The latter had an important sovereign position. We find that she exercised influence upon the internal life of the State whose king she had married, and that she doubled Babylonian influence in Assyria. It is very probable that the legend of the Greeks concerning Semiramis can be traced back to the important position of Samurammat, to whose name, however, whole myths of the goddess Istar have been transferred. Reliefs from the time of Assurbanipal show that the position of the queen was an important one in this time, as well, and a similar conclusion concerning the position of the middle-class woman can be drawn from the documents. * * *

Among the slaves we must distinguish between (1) those that were in the private possession of an individual; (2) the *glebae adscripti,* villeins, who in part had arisen from the condition of slaves, in part had been reduced from the condition of freemen into serfdom; (3) the temple slaves, some of whom were purchased and some presented to the temple by pious citizens or by kings; (4) those belonging to the State, captives of war, of whom the greater part passed into the possession of individuals or of the temple. The first and third classes were employed in industries and about houses, the second in the cultivation of land.

We must consider industry in Babylon as highly developed. A

large number of certificates of delivery have come down to us, from which it appears (1) that private individuals in Babylonia possessed industrial establishments of the nature of factories, and (2) that the temples were great factories. The slaves were let out to work by their masters, and the hire either given to the slave, in case he himself delivered to his master the profit due from him as slave and maintained himself, or, on the other hand, given to the master if the latter provided for the slave's maintenance. Finally, the employer might give the slave his maintenance and the surplus earnings of the slave to the master. In this case the slave also received something for his labors. Thus the slave might accumulate a little capital. Besides, slavery was not as harsh in the Orient as in the Occident. The slave might buy his own freedom, and could be adopted and become a member of the family and rise to the highest places.

If one compares the employer's expenses when slaves were hired with the cost of free laborers, the latter are in most cases considerably more expensive. This appears to contradict an economic law that work under like conditions should receive equal compensation. I believe that I am able to solve the riddle in the following manner: If a free man entered into service, he had no claim for compensation if he became sick or disabled by his work. The slave, on the contrary, must be maintained by his master, and there were laws according to which whoever hired a slave was required to pay an indemnity to his master during the continuance of any disability incurred by the slave while a servant. Slaves were well protected by these exceedingly humane laws. Everyone who hired slaves belonging to others took good care not to disable them by overburdening their strength. As a consequence, the wages for a slave were smaller than those of a free man, who was obliged to forego indemnity if he received an injury from his work.

As for the *glebae adscripti,* they correspond to our tenants by villein service; they had to perform a kind of corvée, that is, they were obliged to work for the landowner on certain days. In most cases these slaves belonged to a temple, and on this account the temple had also jurisdiction over the slaves belonging to it. Fugitive and refractory slaves were put in chains, but might be released upon the guaranty of a comrade. Documents referring to such cases are extant.

Upon military matters in Babylon little has been handed down to us. The foreign rulers of the successive periods had their own national troops, and probably seldom drafted the Babylonians themselves into

military service. These troops gradually became property owners and Babylonians, which explains the clinging to the most ancient custom, namely, that the possession of landed property implied the obligation to furnish soldiers.

From the manner of the origin of the central powers, as sketched above, as well as from the idea that the country was subject to the gods, on the one side, and from the repeated political revolutions on the other, it results, as a matter of course, that out of the tribal possession of the land three forms of ownership must have developed: (1) Temple ownership; (2) State ownership, and (3) only secondarily, private ownership. All three forms are met in the New Babylonian documents, naturally with many variations.

Temple ownership developed out of the proprietary claim upon the whole territory comprised in the district about the temple. Originally a share of the products was yielded on this account to the deity and, therefore, to his temple. Naturally, in the evolution of things, conflicts of rights must have arisen, and thus, even in the oldest documents as yet in the Sumerian language, we see the kings engaged in regulating the temple revenues. Although gradually a partial conversion of the payments in kind into monetary payments took place, the former remained by far the most prevalent, even in the Babylon of Nebuchadnezzar and the Persians, as the contract tablets show. Since, especially in years of bad harvests and in times of war, the revenues established by the kings yielded but little, a fixed income was early provided, inasmuch as certain pieces of land were conveyed not merely into the theoretical proprietorship, but into the actual possession of the temple, in order that from them the expenses of the temple and the priests might be met.

For the form of State ownership we have only slight indications. If the Assyrian kings restored their possessions to the nobles exiled or imprisoned by the Kaldi, and, *vice versa,* the Kaldi kings did the same with regard to those exiled by the Assyrians, this restitution might have taken either the form of *enfeoffment,* of which we have an example in the Merodachbaladan stone of the Berlin Museum, or the form of *restitutio in integrum,* while it is yet impossible to determine certainly whether State or private ownership was really the form in question. So, in the case of a number of revenues, the question is still open whether we have before us taxes upon private property or rents on account of original State ownership. On the other hand a considerable number of documents in proof of genuine private ownership are extant.

If we consider the three forms of proprietorship from the point of view of revenues, it appears that the temples played a double rôle. If they only took a revenue from certain pieces of ground, they were upon the same footing as the State, which received revenues from the feudal estates, but if they held the estates in actual possession they were analogous to private individuals, who could manage these properties themselves or lease them.

We thus come to the subject of husbandry, which we may now divide into the two principal classes, management by the owner and farming on lease. I premise that this refers only to the property-holding classes. The agricultural laborers, that is, the real producers, were either slaves or peasants, who in their village community had gradually come to a certain condition of servitude, either to the temple or to the State or to the nobles. We have, then, to distinguish between the property-holding classes and the agricultural laborers. Naturally, a large number of modifications of condition arose which bridged over the transactions. But, in the rough, for the time which extends from the ascendancy of Assyria over Babylon to the downfall of the former power, that is, from 900 B. C. to about 600 B. C., one may assume as the greatest difference between the two neighboring States—a difference which was also characteristic of the different relation of power—the existence in Assyria of a free peasant class, in distinction to the existence in Babylonia of an unfree peasant class.

That the development of Assyria from a political point of view was much influenced by its social constitution is to be assumed as a matter of course. If, now, we can logically represent this development, we shall be able to judge of the social background, concerning which little documentary evidence remains. The test will be if the little furnished by the inscriptions agrees with the conception previously gained by us.

Now, it is quite easy to trace how the Assyrian kings gradually formed for themselves a military force suitable for rapid movements, and how the latter, originally, indeed, consisting of natives, became more and more a mercenary force recruited from the free lances of all Asia Minor. It is, moreover, clear from the history of Assur from the time of Asurnaçirpal on, that the internal tranquility was greater or less in proportion to the exhibition of power with regard to outside countries. This is explained by the fact that, so long as the surrounding peoples could be forced to pay tribute, the standing army was maintained by this tribute, but when from any cause tribute was less freely

given, the public burden fell more and more heavily upon the producing classes. When, under the kings of the eighth century, the north and east became less productive because of the pressing forward of Aryan tribes, circumstances must have come to such a pass that a complete revolution resulted, which brought Tiglath-Pileser III, and after him, Salmanassar IV, to the throne. Since this revolution took place in opposition to the ruling dynasty, and since neither king gave himself any trouble to establish his legitimacy by artificial pedigrees showing relationship to ancient legendary dynasties, it is probably to be assumed that they effected their usurpation in the face of the hitherto ruling classes of the military and priests by the help of a third factor. This, then, will also explain the fact that after the counter revolution of Sargon, he and his successors seized upon the old broken threads and relied chiefly upon the soldiery and priesthood. If, then, we inquire concerning this third factor, the only answer is that it is to be sought in the ranks of the townspeople and peasants. It is thus made possible to see in the revolution of 745 B. C. the victory of a revolt of peasants. And this, again, is only to be imagined on the hypothesis that in Assyria a strong peasant class unspoiled by servitude had survived. Always presupposing that development had taken place thus, the ascendancy of Assyria over the surrounding powers may be accounted for as the result of the liberated strength of the nation; and, moreover, the easy victory of Sargon, who accomplished the restoration with the aid of the priests, may be explained on the assumption that many years of warfare had shattered the social condition of the peasants.

There are two factors which make possible a verification of these facts. In the first place, the fact that Sargon, after he had seized the power, regulated property rights in favor of the temples, and, consequently, to the prejudice of the townsmen and peasants, who were probably reduced to yet more oppressive dependence. Thence it follows that, before the restoration, temple ownership had been restricted and relations with the temple relaxed, a fact which accordingly supports my representation of the development. And, secondly, the course of Sargon in the foundation of the city Dur-Sharrukin, inasmuch as he boasts that he has accomplished the expropriation of the landowners in a just manner, seems to indicate that a free peasant class had survived even after the restoration. Under the descendants of Sargon, the evolution of conditions probably tended more and more toward the extinction of this class, and thus formed the social groundwork which, after the downfall

of the dynasty, allowed Assyria as well as Babylon to become a Median and Persian province.

Farming on the owner's own account, as we know it from the temple records, was practiced in this manner: Peasants brought their products to the temple storehouses and received for these products receipts from officials appointed for this purpose. It was the same in the case of private owners. It seems, however, as if this kind of management was not very prevalent, or, at any rate, fell into disuse more and more in New Babylon. It was replaced by a system of leasing, which was highly perfected and formed the transition from domestic to commercial management.

I have already stated that the temples farmed out the collection of their revenues; likewise, as with private owners, they rented great tracts of land to contractors. These contractors made a business of renting, inasmuch as they either had the land cultivated on their own account by free or unfree laborers, or leased single pieces again. This sublease was concluded either after exactly the same form as between the first renter and the proprietor or else it was a share rent, so that the property did not give a fixed rent, but a proportionate return, which brought a larger or smaller sum according to the result of the harvest. Such farming on shares was also practiced where renters took property directly under their own management from proprietors. The picture of the economic relations of Babylon which we can thus sketch by the help of the contracts, resembles throughout that of Italy in recent centuries, whose political development, indeed, presents besides many striking analogies to that of Babylon. Fully to show this in detail, however, would lead me far beyond the limits of my essay.

Production was directed primarily toward the gaining of the necessaries of life. If the accounts of the Greeks had not already taught us this, the indigenous inscriptions would, immediately upon their decipherment, have shown that the main stress of social activity in Babylonia was placed upon a quite extraordinarily intensive cultivation of the soil. Innumerable are the receipts for the delivery of grain, of dates, of date litter, date wine, sesame, and garlic, which are found cited here, just as in the accounts of the Egyptian pyramids. And on this subject the accounts of the temples, of which the storehouses appeared to have ruled the market, speak more clearly than anything else. At the same time, the arrangement is especially peculiar, according to which live stock appears not to have been pastured upon the owner's land nor under the

owner's direction, but to have been given into the charge of contractors, who undertook to pasture the herds of various owners, engaged to guard and care for them, and were paid for their services. Here the influx of nomad tribes, with property consisting mainly of herds, and the resulting forms of collective ownership of large tracts of arable land, appears to have led very early to certain compromises with the perfected private ownership of real estate.

The consumption of these products, so far as they were not claimed by the producers themselves, must have taken place in the cities; and since exportation could probably have taken place only on a limited scale—for as far as Arabia the neighboring provinces seem to have produced their own grain—a conclusion as to the size of these cities is thereby justified. But then it is unavoidable to assume a highly flourishing condition of industry in these cities; and, indeed, the textile fabrics of Babylon must have been known and celebrated throughout the whole world of that time. The smith's and carver's arts had likewise attained a high degree of perfection. While, however, the materials for these arts—as metals, stone, and ivory—were not produced in the country, but entered it as objects of exchange for the products of Babylon, the material for weaving was in part obtained in the country. There are yet preserved for us many copies of orders by warrant, of which the temple workers received wool from the temple warehouses in order to make cloth of it; and this wool came not only from the possessions of the Babylonians themselves, but doubtless also from the flocks of the nomadic Aramæans, who became, by reason of having a market for their products, ever more firmly attached to the regions of the Euphrates and the Tigris through which they roamed. It is clear how there may and must have arisen through this development conditions which led to antagonism between plain and city, between pasture and agricultural country, and which were then reflected in the political intrigues according as individual parties represented one or the other interest. And it is clear, further, that with the peculiar growth of temple ownership—as I have developed it above out of the idea of proprietary claim upon the soil—antagonisms must have grown up between the priests or representatives of the interests of the temples and the kings as representatives of the interests of the State. Only by means of this insight into its material condition does the history of Babylon, at the time of the dynasty of Sargon, for instance, become intelligible.

I have already, above, emphasized the fact that the cultivation of

TOWER OF BABEL

From a wood cut after Dore

the land must have been a very intensive one. We see this from pictures which show how water was raised from canals onto the land by means of hydraulic machines; and we can draw this conclusion from the syllabaries published in the second volume of the London work of inscriptions, which deal with the various phases of agriculture. Finally we gather the same knowledge from the data of the lists which, drawn up by the temple officials, show what amount was to be raised in taxes alone from the several tracts of ground. These tracts themselves were distinguished according to the kind of cultivation; those where the clods were broken with the hoe were from this called *aggullattu*—that is, a tool which Tiglath-Pileser I, for example, had used on the construction of roadways in the Armenian highlands. Another kind of tool after which tracts of land were named was the *marru*, written *gish mar*—that is, the ideogram for wood, plus the ideogram *mar*, which is applied to a kind of wagon. Unfortunately the meaning of the word cannot yet be ascertained with precision. While *marru*, in the architectural inscription, is taken by some to mean scoop or bucket, others find in it the meaning wagon tongue. In some of the contracts *marru* certainly means a kind of vessel. It might not be impossible that there were two meanings in the word: (1) that of the vessel, which would then be referred to in the contracts, as well as in the architectural inscriptions; (2) also that of an implement which might perhaps find employment in transportation as well as in agriculture. I imagine it as a primitive kind of cart or dray, and consider it not impossible that by putting in a plowshare a plow might also have been made from it. Further, lands were designated as *zaqpu* to be derived from *zaqaf*, if they were planted with date palms, as *pi shulpi*, if bordering on water and swampy, as *ipinnu*, if watered with the water wheel, and as *taptu*, of which the exact signification as yet eludes definition. Especially in Babylonia the idea of fallow land appears to be lacking, which occurs quite frequently in the Assyrian contracts. Whether here the land actually was or could have been continuously cultivated, without fixed rotation and without pause, I leave undecided.

The individual tracts of land were not computed according to measurements of pure plane geometry, like building plots, but according to measures that had been evolved similar to the German *joch, morgen*, etc.—that is, according to the *gur*, or the real unit of capacity, which about corresponds to the German *wispel* (24 Berlin bushels). According to this, a piece of land was designated by the amount which could

be sowed upon it. Naturally, the ancient method must have been perfected under advanced conditions into a fixed measure of extent; it appears that generally a subdivision of the *gur*—namely, one-tenth of a *qa* (that is, one eighteen-hundredth of the *gur*), with the ideographic denotation *sha. hi. a*, of which I do not know the pronunciation—was fixed as a certain extent of land, which then passed as a unit of measure. It is not yet possible to say anything quite definite as to the size of this unit of measure; Oppert's calculation rests upon false premises. The celebrated assyriologist begins with the unit of linear measure, the ell, and is naturally compelled to construct besides the usual ell a much longer one for land measurement. I believe that I am able to come nearer the truth by a conjecture. If the ground area of a house is measured, it is done by the construction from the linear measure *gi*=*qanu*, (reed, *i. e.*, rod)=7 *u* (*u*=*ammatu*=an ell) of a unit of surface measure, namely, *gi. u*, that is, a surface of which one side was 7 ells, the other, 1 ell long. This construction was carried to such an extent that, if there were subdivisions, these were computed according to the surface unit *gi. shu. si, qanu, uban* (*bohen*) (*mehri haben*)=inch; the unit of measure was accordingly divided into parts, of which one side, equal to 7 ells, remained invariable, while the other side was one or more inches in length. It seems to me now, that the procedure was of like nature in the construction of the surface unit for agricultural land. Since *u* (=*ammatu*) is to be taken as a fundamental unit, according to the accounts of several documents, this ell of land will denote a piece of land, of which the short side was equal to 1 ell, while the long side, however, extended as far as was necessary in order that one *sha. hi. a* might be sowed upon it.

We do not learn very much about the real activity of the peasants. The ground was broken, watered after the sowing, guarded against injury from birds or herds, and the fences around the tracts kept in order. The duty of watching and putting the ditches in order is many times emphasized in the documents of lease. About the harvests and the manner of gathering them there is almost nothing to be gained from the inscriptions.

In the Babylon of Nebuchadnezzar II, the main harvest of grain was in Airu (the Hebrew Iyyar); for dates, in Arah-samma (the Hebrew Marheshwan). It is many times stipulated in the contracts that the grain or the dates to be delivered should be brought to the city by boat, and then delivered either into storehouses or granaries on the quay,

or in the house of the purchaser or of the lessor, respectively. That the waterways, which received careful attention, were used for this transportation, need not excite surprise. Since ship asses are many times mentioned, it might seem as though the boats had been drawn from the bank by asses, but that is probably not correct. According to the representations, rafts of the Assyrians were made of wooden frames, under which were fastened skins of rams, closed and water-tight, and filled with air. Navigation is practiced in similar manner down the river even to-day on the Tigris. At the place of destination the wood is sold along with the cargo, and the skins are piled up and transported back upon asses. Such asses might well be meant in the passages mentioned; nothing, however, is learned from this as to the manner of navigation on the canals.

The laborers had, as a remnant of the ancient domestic management, their full maintenance upon the land, and wages beside. If they were free peasants, these wages came from a share in the produce of the harvest. Slaves received their food and clothing from their masters, and if they were hired, the employers might give them wages as he did to free laborers; from this they paid to their owner the profit due him from a slave, but might, however, claim clothing from him. Therefore, there are also contracts of hire in which the employer pledged himself to furnish the clothing. It happened, besides, that the employer paid the slave's dues to the master, and guaranteed food and clothing, originally without paying the slave himself anything at all. This would seem to have been the earlier, the other the later form; yet nothing conclusive can as yet be established concerning these important questions.

From the part of the crop which now remained over, therefore, as follows from the conditions detailed above, the contractor's rent was to be paid, the owner's income, and the incumbent taxes and imposts. The rent was either a fixed rent or a share rent. In the first case there was fixed the amount of produce or money to be delivered to the owner. We have several such records, but unfortunately the particulars as to the amount of the rent permit of no inference as to its relation to the returns from the harvests. It was otherwise in the case of the share rents. There it was provided that, after deduction of costs, the proceeds were to be divided equally between tenant and owner. There are several statements in which, moreover, it was agreed who should pay the taxes.

The income of the owners of landed property, among whom the temples also are, of course, to be reckoned, came to them, according to

what was said above, in the shape of money or in that of produce. If the latter case prevailed, and this was the rule, there was, naturally, often a hardship for the owner in being compelled to meet his monetary obligations during a period of low prices for grain. On this account, we find an exceedingly large number of texts in which proprietors were forced to mortgage their lands in order to procure money. Nay, more, there even exists a document by which a Babylonian in straits mortgaged his harvest on the stalk.

The necessity of obtaining ready money arose not, perhaps, from private needs alone. The public institutions must many times have co-operated in this respect, as in Rome at the time of the Republic. For, although as already recounted at the outset, the temple imposts and even the direct State taxes were still usually delivered in the form of produce, and accordingly little was at first converted into fixed sums of money, there was another consideration which compelled the use of money. And this was the obligation which rested upon the individual estates to furnish soldiers and their equipment, and likewise to provide for their maintenance. This obligation was probably derived from conditions in which the landowner, as yet a peasant himself, held himself in readiness for service in arms in defense of the country. But, indeed, a mercenary soldiery must have developed in Babylon very early, especially because of the changing foreign rule.

Thus we find documents in which money is appropriated directly to serve for the equipment or maintenance of soldiers. Moreover, this explains the occurrence of the designation of *qashtu* for certain pieces of property; these were just such as had to furnish archers.

Other exactions, to mention these also which, indeed, did not demand a direct expenditure of money, resulted from the public works. For this the organs of administration could constrain the laborers of the temple estates as well as those of private ownership to a kind of corvée, in which their maintenance was furnished by the possessors of the estate.

In Babylon a very important industrial life had developed very early. Of raw products for this, the country had only clay, asphalt and reed in the best quality. All else, for instance, skins of animals, wool, so far as this was not furnished by the tribes which roamed through the country, had to be imported. On this account the kings were very often led to undertake military expeditions toward the Amanus, both in order to keep the way open for traffic and to obtain as tribute what they could

not buy. Babylon must, indeed, have been a gigantic thoroughfare for the trade between the Mediterranean and the Indian Ocean. About this we can learn nothing directly from the cuneiform inscriptions, though we can learn it indirectly, by inferences, and, moreover, from the Greek authors. One thing is nevertheless clear, that great amounts of raw products lay in the storehouses of Babylon.

Production was divided into the work of trades and that of factories. I call trades the activity of free or unfree laborers, because they were entitled to take apprentices and teach them their trade, an institution which fully corresponds to that of our modern trades. We have to look upon the temple and the industrial establishments of the rich citizens as factories. We have a number of certificates of delivery which show how the raw materials were delivered into the industrial establishments and how the finished products were delivered from them. These indicate how long the laborers worked and what amount of wages they received. As soon as the products of the trades came into demand as objects of luxury, craftsmanship touched the boundaries of art. The conditions in question are similar to those which existed in ancient Egypt. Artisanship is a refinement of what is commonly called trade work, which yet cannot attain individuality.

The fine arts were mainly employed upon the royal edifices. Almost every kind of technique was practiced there—metal work (especially embossed work), metal casting, ivory and wood carving, and stone and tile mosaic. The technical perfection of the last was especially remarkable. One is with reason astonished at the blues, partly metallic colors, partly *lapis lazuli,* which were burnt in upon the tiles for mosaics. The bronze doors of Balawat are a splendid relic of the artistic skill of former times. In considering the stone carving it is striking in how masterly a way the hardest stones were subdued in the most remote times, and that, too, with tools with which modern artists cannot work at all. At that time there was as yet no steel. Even the hard basalt was worked with chisels of tempered bronze. Among the minor arts, that of the lapidary is especially to be noticed. We find quite delightful engravings upon the hardest gems. Here, again, is such a technical perfection as could be developed only by the practice of centuries, and which later became lost, so that similar noticeable works could first be produced again only in Italian workshops. Wood carving was employed in the construction of thrones and of little Venus figures in wood. A similar highly developed art appears also in ivory work. Ivory was a much

prized article, for the sake of which the kings often undertook military expeditions, since the elephants were already exterminated on the Euphrates and the Tigris toward the beginning of the tenth century B. C. The ceramics, for which the most excellent raw material was present in all Babylonia, were also remarkable. The clay, which was already washed smooth by the rivers, was ground up so fine that clay writing tablets, for instance, were made of such superlative quality that they could be covered with writing so small as hardly to be read without a microscope.

The Babylonians are our predecessors in the art of printing. We have matrices in clay and in wood. The writing to be multiplied was first carved in wood, then cast in clay, and could then be imprinted upon any number of clay tablets.

A highly developed branch of industry was the art of weaving and embroidery, although we have no specimen of the material. We can form an idea of this art from the representations of the Egyptians and the Babylonians. The Babylonians understood how to weave very thin fabrics as well as the thickest. I myself have seen a clay tablet in London which had been laid upon a piece of linen, so that even now the position of the threads and the excellence of the fabric to which they belonged can be estimated.

The tanner's trade, moreover, was highly developed. This, too, can be judged of only through pictorial representations. According to these, shoes and the harness and saddles of horses were elaborately worked.

Those who carried on industry were partly free, partly slaves; the former received wages, the latter were hired or rented. The owners of the slaves received from the latter, if they were skilled laborers, a fixed income. This must be clearly recognized in the picture of the social relations in Babylon. It is a matter of course, that here the interests of the owners and those of the laborers must have been diverse, and that, in spite of the immense population of Babylon, its political conditions must have been very unstable, because only the rich—that is, the dwindling minority—had an interest in the maintenance of order. Babylon had never been able to attain the position of Rome, where the Plebs constantly obtained more rights.

As for the instruments of labor in Old Babylon, they were not highly developed. On the other hand, a high degree of technical perfection was wrought out with these poor instruments. Among us the

reverse is the case. The tools are very good, but the skill of the human hand has greatly diminished. Whether a division of labor in the modern sense existed in Babylon cannot be yet made clear. There are, nevertheless, a number of facts which would point to it.

According to the representations in the reliefs, the citizens attended public gatherings on state occasions and temple ceremonies, richly adorned and with the insignia which distinguished them as citizens; that is, in flowing garments, with large and artistically made head-dresses, with a seal ring upon the finger, with staff in hand, with girdle and beautifully embroidered leather shoes. In everyday work, on the contrary, we see the same citizens carrying on their business in shirt and apron. Unfortunately, the remains which are at hand come mostly from temples and palaces, and therefore we can form a clear picture only of great state functions.

Several scholars maintain that in Babylon only the temples and palaces are to be considered as great buildings, while the inhabitants lived in primitive huts. This is an untenable view. Portions of foundation walls which belonged to private houses have been discovered, and we are justified in the assumption that Babylon, so long as it existed, made, with its houses, the impression of a great city. One must not forget, withal, that it was an oriental city which required another kind of architecture than that of our great cities. Upon the main streets, which were paved with stone, little outbuildings, such as we still see in oriental cities, which must have served as booths or bazaars, were erected before the houses. There, as in the gates of the temples and palaces, handiwork and traffic were briskly carried on.

Money, the medium of exchange, received its first and best improvement there. It had passed from the conception of barter to the refined conception of value. In even earlier times gold and silver money, and also as subsidiary coinage, copper, bronze, and iron were used. The further the development went the more need there must have been of having the metals in a fixed form and in certain proportions of weight in order that there might be no necessity for weighing the metals each time. It was therefore molded into bars and rings. Unfortunately, no such coins have been preserved, but we have written references to them. The unit of value was the *mine.* This contained 60 *sheqels,* and the latter had again subdivisions, but these varied. From the two first developments of money arises the third; the use of money as capital; that is, interest-bearing capital. We have, in about 2300 B. C., the

transition, as people pledged themselves to work a certain length of time for a sum of money which they must return later.

Exchange was known in Babylon, and there are statements of the changes in value of money. Moreover, the ratio of value between gold and silver was fixed.

This fine development of the relations of value was accompanied by another—the relation of the purchasing power of money to livelihood. A number of documents exist which show that the living expenses of the laborers cannot have been very high, and this agrees with what we know of the Orient from other sources. The soil furnishes the necessaries of life without man's having to take much trouble. Consequently, idleness and beggary are nowhere more widespread than in the Orient. Nowhere is industry urged forward in a more brutal way. There are many reliefs from Babylon and Egypt which show laborers constantly driven by blows from a stick; during the transportation of colossal weights an overseer with a club stands behind every three or four laborers.

## CONCLUSION

During the correction of the preceding sketch, which the editor of the Mittheilungen has sent to the press half against my will, but which I will not now withdraw, since otherwise I should be obliged to let it lie for many years to come without finding the time to work it over thoroughly, two gaps came to my special notice, the filling up of which, however, is subsequently to take place elsewhere. The professional position of the priests will probably be described by Zimmern in his contributions to the knowledge of the Babylonian religion; that of the judges will be treated by Kohler in the fourth part of the work published by Kohler and myself upon Babylonian juridical life.

Translated from Mitteilungen der Vorderasiatischen Gesellschaft, Berlin, 1896.

# PHYSICS

THE MOST IMPORTANT ADVANCES in theoretical Physics during the last thirty years have been connected with the consideration of waves in the ether. In 1873 and even before, J. Clerk Maxwell developed his theory that electricity like light is a wave in the ether. The main proof of this theory rested upon the fact that it could be made to account for electrical phenomena and that the speed of light and electricity seemed to be approximately the same. In 1888 Hertz of Germany succeeded in actually detecting waves in electricity by the method described below. The gradually acquired knowledge of their production and control have resulted in the wireless telegraph, the details of which are given under this head.

The discovery of Crookes' rays and of the X-rays by Röntgen points the way to a knowledge of new forms of radiation.

## JAMES CLERK MAXWELL

JAMES CLERK MAXWELL was born in 1831. He attended Edinburgh from 1847 to 1850, then entered Cambridge and was graduated in 1854, taking the honor of second wrangler.

From 1856 to 1860 he taught in Marichal College, Aberdeen, and from 1860 to 1868 in King's College, London.

He was a mathematician at fifteen, and several of his papers were read before the Royal Society of Edinburgh before he was nineteen. In 1867 he took up the question of electricity and strove to find a theory of it which would not include such a conception as action from a distance. This developed into the theory that electricity is a condition of stress or strain in the ether, in other words, that it is a wave in the same medium as light and travels at the same rate of speed. Hertz's experiments in 1888 have done much to confirm this theory, and such inventions as wireless telegraphy are a direct result.

Maxwell died in 1879.

## ELECTRICITY A WAVE IN THE ETHER

In several parts of this treatise an attempt has been made to explain electromagnetic phenomena by means of mechanical action transmitted from one body to another by means of a medium occupying the space between them. The undulatory theory of light also assumes the existence of a medium. We have now to show that the properties of the electromagnetic medium are identical with those of the luminiferous medium.

To fill all space with a new medium whenever any new phenomenon is to be explained is by no means philosophical, but if the study of two different branches of science has independently suggested the idea of a medium, and if the properties which must be attributed to the medium in order to account for electromagnetic phenomena are of the same kind as those which we attribute to the luminiferous medium in order to account for the phenomena of light, the evidence for the physical existence of the medium will be considerably strengthened.

But the properties of bodies are capable of quantitative measurement. We therefore obtain the numerical value of some property of the medium, such as the velocity with which a disturbance is propagated through it, which can be calculated from electromagnetic experiments, and also observed directly in the case of light. If it should be found that the velocity of propagation of electromagnetic disturbances is the same as the velocity of light, and this not only in air, but in other transparent media, we shall have strong reasons for believing that light is an electromagnetic phenomenon, and the combination of the optical with the electrical evidence will produce a conviction of the reality of the

medium similar to that which we obtain, in the case of other kinds of matter, from the combined evidence of the senses.

When light is emitted, a certain amount of energy is expended by the luminous body, and if the light is absorbed by another body, this body becomes heated, showing that it has received energy from without. During the interval of time after the light left the first body and before it reached the second, it must have existed as energy in the intervening space.

According to the theory of emission, the transmission of energy is effected by the actual transference of light-corpuscules from the luminous to the illuminated body, carrying with them their kinetic energy, together with any other kind of energy of which they may be the receptacles.

According to the theory of undulation, there is a material medium which fills the space between the two bodies, and it is by the action of contiguous parts of this medium that the energy is passed on, from one portion to the next, until it reaches the illuminated body.

The luminiferous medium is therefore, during the passage of light through it, a receptacle of energy. In the undulatory theory, as developed by Huygens, Fresnel, Young, Green, etc., this energy is supposed to be partly potential and partly kinetic. The potential energy is supposed to be due to the distortion of the elementary portions of the medium. We must therefore regard the medium as elastic. The kinetic energy is supposed to be due to the vibratory motion of the medium. We must therefore regard the medium as having a finite density.

In the theory of electricity and magnetism adopted in this treatise, two forms of energy are recognised, the electrostatic and the electrokinetic, and these are supposed to have their seat, not merely in the electrified or magnetized bodies, but in every part of the surrounding space, where electric or magnetic force is observed to act. Hence our theory agrees with the undulatory theory in assuming the existence of a medium which is capable of becoming a receptacle of two forms of energy.

Let us next determine the conditions of the propagation of an electromagnetic disturbance through a uniform medium, which we shall suppose to be at rest, that is, to have no motion except that which may be involved in electromagnetic disturbances.

Let $C$ be the specific conductivity of the medium, $K$ its specific capacity for electrostatic induction, and $\mu$ its magnetic "permeability."

The quantity $V$, in Art. 784, which expresses the velocity of propagation of electromagnetic disturbances in a non-conducting medium is, by equation (10), equal to $\frac{1}{\sqrt{Ku}}$.

If the medium is air, and if we adopt the electrostatic system of measurement, $K=1$ and $u=\frac{1}{v^2}$, so that $V=v$, or the velocity of propagation is numerically equal to the number of electrostatic units of electricity in one electromagnetic unit. If we adopt the electromagnetic system, $K=\frac{1}{v^2}$ and $u=1$, so that the equation $V=v$ is still true.

On the theory that light is an electromagnetic disturbance, propagated in the same medium through which other electromagnetic actions are transmitted, $V$ must be the velocity of light, a quantity the value of which has been estimated by several methods. On the other hand, $v$ is the number of electrostatic units of electricity in one electromagnetic unit, and the methods of determining this quantity have been described in the last chapter. [Here inserted.]

*Comparison of Units of Electricity*

[Since the ratio of the electromagnetic to the electrostatic unit of electricity is represented by a velocity, we shall in future denote it by the symbol $v$. The first numerical determination of this velocity was made by Weber and Kohlrausch.

Their method was founded on the measurement of the same quantity of electricity, first in electrostatic and then in electromagnetic measure.

The quantity of electricity measured was the charge of a Leyden jar. It was measured in electrostatic measure as the product of the capacity of the jar into the difference of potential of its coatings. The capacity of the jar was determined by comparison with that of a sphere suspended in an open space at a distance from other bodies. The capacity of such a sphere is expressed in electrostatic measure by its radius. Thus the capacity of the jar may be found and expressed as a certain length. See Art. 227.

The difference of the potentials of the coatings of the jar was measured by connecting the coatings with the electrodes of an electrometer,

the constants of which were carefully determined, so that the difference of the potentials, $E$, became known in electrostatic measure.

By multiplying this by $c$, the capacity of the jar, the charge of the jar was expressed in electrostatic measure.

To determine the value of the charge in electromagnetic measure, the jar was discharged through the coil of a galvanometer. The effect of the transient current on the magnet of the galvanometer communicated to the magnet a certain angular velocity. The magnet then swung round to a certain deviation, at which its velocity was entirely destroyed by the opposing action of the earth's magnetism.

By observing the extreme deviation of the magnet the quantity of electricity in the discharge may be determined in electromagnetic measure, as in Art. 748, by the formula

$$Q = \frac{H}{G}\frac{T}{n} 2 \sin \tfrac{1}{2} O,$$

where $Q$ is the quantity of electricity in electromagnetic measure. We have therefore to determine the following quantities:

$H$, the intensity of the horizontal component of terrestrial magnetism; see Art. 456.

$G$, the principal constant of the galvanometer; see Art. 700.

$T$, the time of a single vibration of the magnet; and

$O$, the deviation due to the transient current.

The value of $v$ obtained by MM. Weber and Kohlrausch was

$$v = 310740000 \text{ metres per second.}$$

The property of solid dielectrics, to which the name of Electric Absorption has been given, renders it difficult to estimate correctly the capacity of a Leyden jar. The apparent capacity varies according to the time which elapses between the charging or discharging of the jar and the measurement of the potential, and the longer the time the greater is the value obtained for the capacity of the jar.

Hence, since the time occupied in obtaining a reading of the electrometer is large in comparison with the time during which the discharge through the galvanometer takes place, it is probable that the estimate of the discharge in electrostatic measure is too high, and the value of $v$, derived from it, is probably also too high.]

They are quite independent of the methods of finding the velocity of light. Hence the agreement or disagreement of the values of $V$ and of $v$ furnishes a test of the electromagnetic theory of light.

In the following table, the principal results of direct observation of the velocity of light, either through the air or through the planetary spaces, are compared with the principal results of the comparison of the electric units:—

| Velocity of Light (metres per second). | | Ratio of Electric Units (metres per second). | |
|---|---|---|---|
| Fizeau | 314000000 | Weber | 310740000 |
| Aberration, etc., and Sun's Parallax | 308000000 | Maxwell | 288000000 |
| Foucault | 298360000 | Thomson | 282000000 |

It is manifest that the velocity of light and the ratio of the units are quantities of the same order of magnitude. Neither of them can be said to be determined as yet with such a degree of accuracy as to enable us to assert that the one is greater or less than the other. It is to be hoped that, by further experiment, the relation between the magnitudes of the two quantities may be more accurately determined.

In the meantime our theory, which asserts that these two quantities are equal, and assigns a physical reason for this equality, is certainly not contradicted by the comparisons of these results such as they are.

In the following table, taken from a paper by E. B. Rosa, *Phil. Mag.* 28, p. 315, 1889, the determinations of '$v$' corrected for the error in the B. A. unit are given:—

| | | |
|---|---|---|
| 1856 | Weber and Kohlrausch | $3.107 \times 10^{10}$ (cm. per second) |
| 1868 | Maxwell | $2.842 \times 10^{10}$ |
| 1869 | W. Thomson and King | $2.808 \times 10^{10}$ |
| 1872 | McKichan | $2.896 \times 10^{10}$ |
| 1879 | Ayrton and Perry | $2.960 \times 10^{10}$ |
| 1880 | Shida | $2.955 \times 10^{10}$ |
| 1883 | J. J. Thomson | $2.963 \times 10^{10}$ |
| 1884 | Klemencic | $3.019 \times 10^{10}$ |
| 1888 | Himstedt | $3.009 \times 10^{10}$ |
| 1889 | W. Thomson | $3.004 \times 10^{10}$ |
| 1889 | E. B. Rosa | $2.9993 \times 10^{10}$ |
| 1890 | J. J. Thomson and Searle | $2.9955 \times 10^{10}$ |

VELOCITY OF LIGHT IN AIR.

| | |
|---|---|
| Cornu (1878) | $3.003 \times 10^{10}$ |
| Michelson (1879) | $2.9982 \times 10^{10}$ |
| Michelson (1882) | $2.9976 \times 10^{10}$ |
| Newcomb (1885) | $\left\{\begin{matrix} 2.99615 \\ 2.99682 \\ 2.99766 \end{matrix}\right\} \times 10^{10}$ |

In other media than air, the velocity $V$ is inversely proportional to the square root of the product of the dielectric and the magnetic inductive capacities. According to the undulatory theory, the velocity of light in different media is inversely proportional to their indices of refraction.

There are no transparent media for which the magnetic capacity differs from that of air more than by a very small fraction. Hence the principal part of the difference between these media must depend on

their dielectric capacity. According to our theory, therefore, the dielectric capacity of a transparent medium should be equal to the square of its index of refraction.

But the value of the index of refraction is different for light of different kinds, being greater for light of more rapid vibrations. We must therefore select the index of refraction which corresponds to waves of the longest periods, because these are the only waves whose motion can be compared with the slow processes by which we determine the capacity of the dielectric.

The only dielectric of which the capacity has been hitherto determined with sufficient accuracy is paraffin, for which in the solid form MM. Gibson and Barclay found.

$$K = 1.975.$$

Dr. Gladstone has found the following values of the index of refraction of melted paraffin, sp. g. 0.779, for the lines $A$, $D$ and $H$:—

| Temperature | $A$ | $D$ | $H$ |
|---|---|---|---|
| 54°C | 1.4306 | 1.4357 | 1.4499 |
| 57°C | 1.4294 | 1.4343 | 1.4493 |

from which I find that the index of refraction for waves of infinite length would be about 1.422.

The square root of $K$ is 1.405.

The difference between these numbers is greater than can be accounted for by errors of observation, and shows that our theories of the structure of bodies must be much improved before we can deduce their optical from their electrical properties. At the same time, I think that the agreement of the numbers is such that if no greater discrepancy were found between the numbers derived from the optical and the electrical properties of a considerable number of substances, we should be warranted in concluding that the square root of $K$, though it may not be the complete expression for the index of refraction, is at least the most important term in it.

# M. HENRI POINCARE

## THE MAXWELL AND HERTZ THEORY OF ELECTRICITY AND LIGHT

It was at the moment when the experiments of Fresnel were forcing the scientific world to admit that light consists of the vibrations of a highly attentuated fluid filling interplanetary spaces that the researches of Ampère were making known the laws of the mutual action of currents and were so enunciating the fundamental principles of electrodynamics.

It needed but one step to the supposition that that same fluid, the ether, which is the medium of luminous phenomena, is at the same time the vehicle of electrical action. In imagination Ampère made this stride; but the illustrious physicist could not foresee that the seducing hypothesis with which he was toying, a mere dream for him, was ere long to take a precise form and become one of the vital concerns of exact science.

A dream it remained for many years, till one day, after electrical measurements had become extremely exact, some physicist, turning over the numerical data, much as a resting pedestrian might idly turn over a stone, brought to light an odd coincidence. It was that the factor of transformation between the system of electro-statical units and the system of electro-dynamical units was equal to the velocity of light. Soon the observations directed to this strange coincidence became so exact that no sane head could longer hold it a mere coincidence. No longer could it be doubted that some occult affinity existed between optical and electrical phenomena. Perhaps, however, we might be wondering to this day what this affinity could be were it not for the genius of Clerk Maxwell.

### *Displacement Currents*

The reader is aware that solid bodies are divided into two classes, conductors through which electricity can move in the form of a galvanic current, and nonconductors, or dielectrics. The electricians of former

days regarded dielectrics as quite inert, having no part to play but that of obstinately refusing passage to electricity. Had that been so, any one nonconductor might be replaced by any other without making any difference in the phenomena; but Faraday found that that was not the case. Two condensers of the same form and dimensions put into connection with the same source of electricity do not take the same charge, though the thickness of the isolating plate be the same, unless the matter of that plate be chemically the same. Now Clerk Maxwell had too deeply studied the researches of Faraday not to comprehend the importance of dielectrics and the imperative obligation to recognize their active part.

Besides, if light is but an electric phenomenon, when it traverses a thickness of glass electrical events must take place in that glass. And what can be the nature of those events? Maxwell boldly answers, they are, and must be, currents.

All the experience of his day seemed to contradict this. Never had currents been observed except in conductors. How was Maxwell to reconcile his audacious hypothesis with a fact so well established as that? Why is it that under certain circumstances those supposed currents produce manifest effects, while under ordinary conditions they can not be observed at all.

The answer was that dielectrics resist the passage of electricity not so much more than conductors do, but in a different manner. Maxwell's idea will best be understood by a comparison.

If we bend a spring, we meet a resistance which increases the more the spring is bended. So, if we can only dispose of a finite force, a moment will come when the motion will cease, equilibrium being reached. Finally, when the force ceases the spring will in flying back restore the whole of the energy which has been expended in bending it.

Suppose, on the other hand, that we wish to displace a body plunged into water. Here again a resistance will be experienced, but it will not go on increasing in proportion as the body advances, supposing it to be maintained at a constant velocity. So long as the motive force acts, equilibrium will never, then, be attained; nor when the force is removed will the body in the least tend to return, nor can any portion of the energy expended be restored. It will, in fact, have been converted into heat by the viscosity of the water.

The contrast is plain; and we ought to distinguish elastic resistance from viscous resistance. Using these terms, we may express Maxwell's

idea by saying that dielectrics offer an elastic resistance, conductors a viscous resistance, to the movements of electricity. Hence, there are two kinds of currents; currents of displacement which traverse dielectrics and ordinary currents of conduction which circulate in conductors.

Currents of the first kind, having to overcome an elastic resistance which continually increases, naturally can last but a very short time, since a state of equilibrium will quickly be reached.

Currents of conduction, on the other hand, having only a viscous resistance to overcome, must continue so long as there is any electromotive force.

Let us return to the simile used by M. Cornu in his notice in the Annuaire du Bureau des Longitudes for 1893. Suppose we have in a reservoir water under pressure. Lead a tube plumb downward into the reservoir. The water will rise in the tube, but the rise will stop when hydrostatic equilibrium is attained—that is, when the downward pressure of the water in the tube above the point of application of the first pressure on the reservoir, and due to the weight of the water, balances that first pressure. If the pipe is large, there will be no friction or loss of head, and the water so raised can be used to do work. That represents a current of displacement.

If, on the other hand, the water flows out of the reservoir by a horizontal pipe, the motion will go on till the reservoir is emptied; but if the tube is small and long there will be a great loss of energy and considerable production of heat by friction. That represents a current of conduction.

Though it would be vain, not to say idle, to attempt to represent all details, it may be said that everything happens just as if the currents of displacement were acting to bend a multitude of little springs. When the currents cease, electrostatic equilibrium is established, and the springs are bent the more, the more intense is the electric field. The accumulated work of the springs—that is, the electrostatic energy—can be entirely restored as soon as they can unbend, and so it is that we obtain mechanical work when we leave the conductors to obey the electrostatic attractions. Those attractions must be due to the pressure exercised on the conductors by the bent springs. Finally, to pursue the image to the death, the disruptive discharge may be compared to the breaking of the springs when they are bent too much.

On the other hand, the energy employed to produce conduction currents is lost, being wholly converted into heat, like that spent in over-

coming the viscosity of fluids. Hence it is that the conducting wires become heated.

From Maxwell's point of view it seems that all currents are in closed circuits. The older electricians did not so opine. They regarded the current circulating in a wire joining the two poles of a pile as closed; but if in place of directly uniting the two poles we place them in communication with the two armatures of a condenser, the momentary current which lasts while the condenser is getting charged was not considered as a current round a closed circuit. It went, they thought, from one armature through the wire, the battery, the other wire, to the other armature, and there it stopped. Maxwell, on the contrary, supposed that in the form of a current of displacement it passes through the nonconducting plate of the condenser, and that precisely what brings it to cessation is the opposite electromotive force set up by the displacement of electricity in this dielectric.

Currents become sensible in three ways—by their heating effects, by their actions on other currents and on magnets, and by the induced currents to which they give rise. We have seen why currents of conduction develop heat and why currents of displacement do not. But Maxwell's hypothetical currents ought at any rate to produce electromagnetic and inductive effects. Why do these effects not appear? The answer is, that it is because a current of displacement can not last long enough. That is to say, they can not last long in one direction. Consequently in a dielectric no current can long exist without alternation. But the effects ought to and will become observable if the current is continually reversed at sufficiently short intervals.

*The Nature of Light*

Such, according to Maxwell, is the origin of light. A luminiferous wave is a series of alternating currents produced in dielectrics, in air, or even in the interplanetary void, and reversed in direction a million of million of times per second. The enormous induction due to these frequent alternations sets up other currents in the neighboring parts of the dielectric, and so the waves are propagated.

Calculation shows that the velocity of propagation would be equal to the ratio of the units, which we know is the velocity of light.

Those alternative currents are a sort of electrical oscillation. Are they longitudinal, like those of sound, or are they transversal, like those of Fresnel's ether? In the case of sound the air undergoes alternative condensations and rarefactions. The ether of Fresnel, on the other

hand, behaves as if it were composed of incompressible layers capable only of slipping over one another. Were these currents in open paths, the electricity carried from one end to the other would become accumulated at one extremity. It would thus be condensed and rarefied like air, and its vibrations would be longitudinal. But Maxwell only admits currents in closed circuits; accumulation is impossible, and electricity behaves like the incompressible ether of Fresnel, with its transversal vibrations.

*Experimental Verification*

We thus obtain all the results of the theory of waves. Yet this was not enough to decide the physicists to adopt the ideas of Maxwell. It was a seductive hypothesis; but physicists consider hypotheses which lead to no distinct observational consequences as beyond the borders of their province. That province, so defined, no experimental confirmation of Maxwell's theory invaded for twenty-five years.

What was wanted was some issue between the two theories not too delicate for our coarse methods of observation to decide. There was but one line of research along which any *experimentum crucis* was to be met with.

The old electro-dynamics makes electro-magnetic induction take place instantaneously; but according to Maxwell's doctrine it propagates itself with the velocity of light.

The point was then to measure, or at least to make certain, a velocity of propagation of inductive effects. This is what the illustrious German physicist Hertz has done by the method of interferences.

The method is well known in its application to optical phenomena. Two luminous rays from one identical center interfere when they reach the same point after pursuing paths of different lengths. If the difference is one, two, or any whole number of wave lengths, the two lights re-enforce one another so that if their intensities are equal, that of their combination is four times as great. But if the difference is an odd number of half wave lengths, the two lights extinguish one another.

Luminiferous waves are not peculiar in showing this phenomenon; it belongs to every periodic change which is propagated with definite velocity. Sound interferes just as light does, and so must electro-dynamic induction if it is strictly periodic and has a definite velocity of propagation. But if the propagation is instantaneous there can be no interference, since in that case there is no finite wave length.

The phenomenon, however, could not be observed were the wave length greater than the distance within which induction is sensible. It is therefore requisite to make the period of alternation as short as possible.

*Electrical Exciters*

We can obtain such currents by means of an apparatus which constitutes a veritable electrical pendulum. Let two conductors be united by a wire. If they have not the same electric potential the electrical equilibrium is disturbed and tends to restore itself, just as the molar equilibrium is disturbed when a pendulum is carried away from the position of repose.

A current is set up in the wire, tending to equalize the potential, just as the pendulum begins to move so as to be carried back to the position of repose. But the pendulum does not stop when it reaches that position. Its inertia carries it farther. Nor, when the two electrical conductors reach the same potentia., does the current in the wire cease. The equilibrium instantaneously existing is at once destroyed by a cause analogous to inertia, namely self-induction. We know that when a current is interrupted it gives rise in parallel wires to an induced current in the same direction. The same effect is produced in the circuit itself, if that is not broken. In other words, a current will persist after the cessation of its causes, just as a moving body does not stop the instant it is no longer driven forward.

When, then, the two potentials become equal, the current will go on and give the two conductors relative charges opposite to those they had at first. In this case, as in that of the pendulum, the position of equilibrium is passed, and a return motion is inevitable. Equilibrium, again instantaneously attained, is at once again broken for the same reason; and so the oscillations pursue one another unceasingly.

Calculation shows that the period depends on the capacity of the conductors in such a way that it is only necessary to diminish that capacity sufficiently (which is easily done) to have an electric pendulum capable of producing an alternating current of extremely short period.

All that was well enough known by the theoretical researches of Lord Kelvin and by the experimentation of Federson on the oscillatory discharge of the Leyden jar. It was not that which constituted the originality of Hertz.

But it is not enough to construct a pendulum; it is further requisite to set it into oscillation. For that, it is necessary to carry it off from equilibrium and to let it go suddenly, that is to say, to release it in a time short as compared to the period of its oscillation.

For if, having pulled a pendulum to one side by a string, we were to let go of the string more slowly that the pendulum would have descended of itself, it would reach the vertical without momentum, and no oscillation would be set up.

In like manner, with an electric pendulum whose natural period is, say, a hundred-millionth of a second, no mechanical mode of release would answer the purpose at all, sudden as it might seem to us with our more than sluggish conceptions of promptitude. How, then, did Hertz solve the problem?

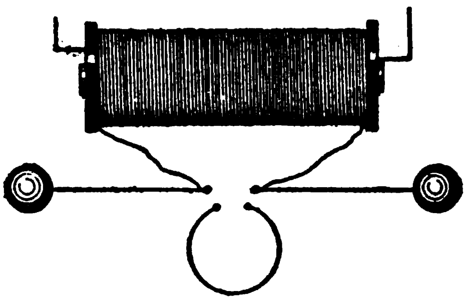


FIG. 1. The Hertz Exciter.

To return to our electric pendulum, a gap of a few millimeters is made in the wire which joins the two conductors. This gap divides our apparatus into two symmetrical parts, which are connected to the two poles of a Ruhmkorff coil. The induced current begins to charge the two conductors, and the difference of their potential increases with relative slowness.

At first the gap prevents a discharge from the conductors; the air in it plays the rôle of insulator and maintains our pendulum in a position diverted from that of equilibrium.

But when the difference of potential becomes great enough, a spark will jump across. If the self-induction is great enough and the capacity and resistance small enough, there will be an oscillatory discharge whose period can be brought down to a hundred-millionth of a second.

The oscillatory discharge would not, it is true, last long by itself; but it is kept up by the Ruhmkorff coil, whose current is itself oscillatory with a period of about a hundred-thousandth of a second, and thus the pendulum gets a new impulse as often as that.

The instrument just described is called a resonance exciter. It produces oscillations which are reversed from a hundred million to a thousand million times per second. Thanks to this extreme frequency, they can produce inductive effects at great distances. To make these effects sensible another electric pendulum is used, called a resonator. In this the coil is suppressed. It consists simply of two little metallic spheres very near to one another, with a long wire connecting them in a roundabout way.

The induction due to the exciter will set the reasonator in vibration the more intensely the more nearly the natural periods of vibration are the same. At certain phases of the vibration the difference of potential of the two spheres will be just great enough to cause the sparks to leap across.

*Production of the Interferences*

Thus we have an instrument which reveals the inductive waves which radiate from the exciter. We can study them in two ways. We may either expose the resonator to the direct induction of the exciter at a great distance, or else make this induction act at a small distance on a long conducting wire which the electric wave will follow and which in its turn will act at a small distance on the resonator.

Whether the wave is propagated along a wire or across the air, interferences can be produced by reflection. In the first case it will be reflected at the extremity of the wire, which it will again pass through in the opposite direction. In the second case it can be reflected on a metallic leaf which will act as a mirror. In either case the reflected ray will interfere with the direct ray, and positions will be found in which the spark of the resonator will be extinguished.

Experiments with a long wire are the easier and furnish much valuable information, but they cannot furnish an *experimentum crucis,* since in the old theory, as in the new, the velocity of the electric wave in a wire should be equal to that of light. But experiments on direct induction at great distances are decisive. They not only show that the velocity of propagation of induction across air is finite, but also that it is equal to the velocity of the wave propagated along a wire, conformably to the ideas of Maxwell.

### *Synthesis of Light*

I shall insist less on other experiments of Hertz, more brilliant but less instructive. Concentrating with a parabolic mirror the wave of induction that emanates from the exciter, the German physicist obtained a true pencil of rays of electric force, susceptible of regular reflection and refraction. These rays, were the period but one-millionth of what it is, would not differ from rays of light. We know that the sun sends us several varieties of radiations, some luminiferous, since they act on the retina, others dark, infra-red, or ultra-violet, which reveal themselves in chemical and calorific effects. The first owe the qualities which render them sensible to us to a physiological chance. For the physicist, the infra-red differs from red only as red differs from green; it simply has a greater wave length. That of the Hertzian radiations is far greater still, but they are mere differences of degree, and if the ideas of Clerk Maxwell are true, the illustrious professor of Bonn has effected a genuine synthesis of light.

### *Conclusion*

Nevertheless, our admiration for such unhoped-for successes must not let us forget what remains to be accomplished. Let us endeavor to take exact account of the results definitely acquired.

In the first place, the velocity of direct induction through air is finite; for otherwise interferences could not exist. Thus the old electrodynamics is condemned. But what is to be set up in its place? Is it to be the doctrine of Maxwell, or rather some approximation to that, for it would be too much to suppose that he had foreseen the truth in all its details? Though the probabilities are accumulating, no complete demonstration of that doctrine has ever attained.

We can measure the wave length of the Hertzian oscillations. That length is the product of the period into the velocity of propagation. We should know the velocity if we knew the period; but this last is so minute that we cannot measure it; we can only calculate it by a formula due to Lord Kelvin. That calculation leads to figures agreeable to the theory of Maxwell; but the last doubts will only be dissipated when the velocity of propagation has been directly measured. (See Note I.)

But this is not all. Matters are far from being as simple as this brief account of the matter would lead one to think. There are various complications.

In the first place, there is around the exciter a true radiation of

induction. The energy of the apparatus radiates abroad, and if no source feeds it, it quickly dissipates itself and the oscillations are rapidly extinguished. Hence arises the phenomenon of multiple resonance, discovered by Messrs. Sarasin and De la Rive, which at first seemed irreconcilable with the theory.

On the other hand, we know that light does not exactly follow the laws of geometrical optics, and the discrepancy, due to diffraction, increases proportionately to the wave length. With the great waves of the Hertzian undulations these phenomena must assume enormous importance and derange everything. It is doubtless fortunate, for the moment at least, that our means of observation are as coarse as they are, for otherwise the simplicity which struck us would give place to a dedalian complexity in which we should lose our way. No doubt a good many perplexing anomalies have been due to this. For the same reason the experiments to prove a refraction of the electrical waves can hardly be considered as demonstrative.

It remains to speak of a difficulty still more grave, though doubtless not insurmountable. According to Maxwell, the coefficient of electrostatic induction of a transparent body ought to be equal to the square of its index of refraction. Now this is not so. The few bodies which follow Maxwell's law are exceptions. The phenomena are plainly far more complex than was at first thought. But we have not yet been able to make out how matters stand, and the experiments conflict with one another.

Much, then, remains to be done. The identity of light with a vibratory motion in electricity is henceforth something more than a seductive hypothesis; it is a probable truth. But it is not yet quite proved.

Note I.—Since the above was written another great step has been taken. M. Blondlot has virtually succeeded, by ingenious experimental contrivances, in directly measuring the velocity of a disturbance along a wire. The number found differs little from the ratio of the units; that is, from the velocity of light, which is 300,000 kilometers per second. Since the interference experiments made at Geneva by Messrs. Sarasin and De la Rive have shown, as I said above, that induction is propagated in air with the same velocity as an electric disturbance which follows a conducting wire, we must conclude that the velocity of the induction is the same as that of light, which is a confirmation of the ideas of Maxwell.

M. Fizeau had formerly found for the velocity of electricity a

number far smaller, about 180,000 kilometers. But there is no contradiction. The currents used by M. Fizeau, though intermittent, were of small frequency and penetrated to the axis of the wire, while the currents of M. Blondlot, oscillatory and of very short period, remained superficial and were confined to a layer of less than a hundredth of a millimeter in thickness. One may readily suppose the laws of propagation are not the same in the two cases.

NOTE II.—I have endeavored above to render the explanation of the electrostatic attractions and of the phenomena of induction comprehensible by means of a simile. Now let us see what Maxwell's idea is of the cause which produces the mutual attractions of currents.

While the electrostatic attractions are taken to be due to a multitude of little springs—that is to say, to the elasticity of the ether—it is supposed to be the living force and inertia of the same fluid which produce the phenomena of induction and electrodynamical effects.

The complete calculation is far too extended for these pages, and I shall again content myself with a simile. I shall borrow it from a well known instrument—the centrifugal governor.

The living force of this apparatus is proportional to the square of the angular velocity and to the square of the distance of the balls.

According to the hypothesis of Maxwell, the ether is in motion in galvanic currents, and its living force is proportional to the square of the intensity of the current, which thus correspond, in the parallel I am endeavoring to establish, to the angular velocity of rotation.

If we consider two currents in the same direction, the living force, with equal intensity, will be greater the nearer the currents are to one another. If the currents have opposite directions, the living force will be greater the farther they are apart.

In order to increase the angular velocity of the regulator and consequently its living force, it is necessary to supply it with energy and consequently to overcome a resistance which we call its inertia.

In the same way, in order to increase the intensity of a current, we must augment the living force of the ether, and it will be necessary to supply it with energy and to overcome a resistance which is nothing but the inertia of the ether and which we call the induction.

The living force will be greater if the currents are in the same direction and near together. The energy to be furnished the counter electromotive force of induction will be greater. This is what we express when we say that the mutual action of two currents is to be added

to their self-induction. The contrary is the case when their directions are opposite.

If we separate the balls of the regulator, it will be necessary, in order to maintain the angular velocity, to furnish energy, because with equal angular velocity the living force is greater the more the balls are separated.

In the same way, if two currents have the same direction and are brought toward one another, it will be necessary, in order to maintain the intensity to supply energy, because the living force will be augmented. We shall, therefore, have to overcome an electromotive force of induction which will tend to diminish the intensity of the currents. It would tend on the contrary to augment it, if the currents had the same direction and were carried apart, or if they had opposite directions and were brought together.

Finally, the centrifugal force tends to increase the distance between the balls, which would augment the living force were the angular velocity to be maintained.

In like manner, when the currents have the same direction, they attract each other—that is to say, they tend to approach each other, which would increase the living force if the intensity were maintained. If their directions are opposed they repel one another and tend to separate, which would again tend to increase the living force were the intensity kept constant.

Thus the electrostatic effects would be due to the elasticity of the ether and the electrodynamical phenomena to the living force. Now, ought this elasticity itself to be explained, as Lord Kelvin thinks, by rotations of small parts of the fluid? Different reasons may render this hypothesis attractive; but it plays no essential part in the theory of Maxwell, which is quite independent of it.

In the same way, I have made comparisons with divers mechanisms. But they are only similes, and pretty rough ones. A complete mechanical explanation of electrical phenomena is not to be sought in the volumes of Maxwell, but only a statement of the conditions which any such explanation has to satisfy. Precisely what will confer long life on the work of Maxwell is its being unentangled with any special mechanical hypothesis.

# W. K. RÖNTGEN

WILHELM KONRAD VON ROENTGEN was born at Lennep, Prussia, in 1845. He was educated at Zurich, and became professor of physics at Strasburg, and in 1885 at Würzburg. His discovery of the so-called X-rays was made in 1895.

## THE X-RAYS

### I.—UPON A NEW KIND OF RAYS

1. If the discharge of a great Ruhmkorff induction coil be passed through a Hittorf vacuum tube, or a Lenard's, Crookes', or similar apparatus containing a sufficiently high vacuum, then, the tube being covered with a close layer of thin black pasteboard and the room darkened, a paper screen covered on one side with barium-platinum cyanide and brought near the apparatus will be seen to glow brightly and fluoresce at each discharge whichever side of the screen is toward the vacuum tube. The fluorescence is visible even when the screen is removed to a distance of 2 meters from the apparatus.

The observer may easily satisfy himself that the cause of the fluorescence is to be found at the vacuum tube and at no other part of the electrical circuit.

2. It is thus apparent that there is here an agency which is able to pass through the black pasteboard impenetrable to visible or ultra violet rays from the sun or the electric arc, and having passed through is capable of exciting a lively fluorescence, and it is natural to inquire whether other substances can be thus penetrated.

It is found that all substances transmit this agency, but in very different degree. I will mention some examples. Paper is very transmissible.

I observed fluorescence very distinctly behind a bound book of about 1,000 pages. The ink presented no appreciable obstacle. Similarly fluorescence was seen behind a double whist pack. A single card

# W. K. RÖNTGEN

[illegible] Konrad von R[illegible]ntgen was born at Lennep, Pr[illegible] [illegible]. He was educated at Zurich, and became professor [illegible] at [illegible], and in 1885 at Würzburg. His discovery of the so-called [illegible] was made in 1895.

## THE X-RAYS

### I.—UPON A NEW KIND OF RAYS

1. If the discharge of a [illegible] Ruhmkorff induction coil be pass[illegible] through a Hittorf vacuum tube, or a Lenard's, Crookes', or similar apparatus containing a sufficiently high vacuum, then, the tube being covered with a close layer of [illegible] black pasteboard and the room darkened, a paper screen covered on one side with barium-platinum cyanide [illegible] brought near the apparatus will be seen to glow brightly and [illegible] at each discharge, whichever side of the screen is toward the [illegible] tube. The fluorescence is visible even when the screen is [illegible] distance of 2 meters from the apparatus.

The observer may easily satisfy himself that the cause of the fluorescence is to be found at the vacuum tube and at no other part of the electrical circuit.

2. It is thus apparent that there is here an agency which is able [illegible] pass through the black pasteboard impenetrable to visible or [illegible] [illegible] of the electric arc, and having passed [illegible] [illegible] of exciting a lively fluorescence, and it is natural to [illegible] [illegible] substances can be thus penetrated.

[illegible] that all substances transmit this agency, but in [illegible] [illegible] I will mention some examples. Paper is very trans[illegible] [illegible]

[illegible] fluorescence very distinctly behind a bound book of [illegible] pages. The ink presented no appreciable obst[illegible] [illegible] fluorescence was seen behind a double whist pack. A single car[illegible]

held between the fluorescent screen and the apparatus produced no visible effect. A single sheet of tin foil, too, produces hardly any obstacle, and it is only when several sheets are superposed that their shadow appears distinctly on the screen. Thick wooden blocks are transmissible. Slabs of pine 2 or 3 centimeters thick absorb only very little. A plate of aluminum about 15 millimeters thick diminished the effect very considerably, but did not cause the fluorescence to entirely disappear. Blocks of hard rubber several centimeters thick still transmitted the rays.

Glass plates of equal thickness behave very differently according to whether they contain lead (flint glass) or not. The first class are much less transmissible than the second.

If the hand is held between the vacuum tube and the screen, the dark shadow of the bones is seen upon the much lighter shadow outline of the hand. Water, carbon, bisulphide, and various other liquids investigated proved very transmissible. I could not find that hydrogen was more transmissible than air. The fluorescence was visible behind plates of copper, silver, lead, gold, and platinum, when the thickness of the plate was not too great. Platinum 0.2 millimeter thick is still transmissible, and silver and copper plates may be still thicker. Lead 1.5 millimeters thick is practically impenetrable, and advantage was frequently taken of this characteristic. A wooden stick of 20 millimeters square cross section, having one side covered with white lead, behaved differently when interposed between the vacuum tube and the screen according as the X-rays traversed the block parallel to the painted side or were compelled to pass through it. In the first case there was no effect appreciable, while in the second a dark shadow was thrown on the screen. Salts of the metals, whether solid or in solution, are to be ranged in almost the same order as the metals themselves for transmissibility.

3. These observations and others lead to the conclusion that the transmissibility of equal thicknesses of different substances depends on their density. At least no other characteristic exerts so marked an influence as this.

The following experiment shows, however, that the density is not the sole factor. I compared the transmissibility of nearly equally thick plates of glass, aluminum, calcspar, and quartz. The density of these substances is substantially the same, and yet it was quite evident that the calcspar was considerably less transmissible than the others, which are about alike in this respect.

4. All bodies became less transmissible with increasing thickness. For the purpose of finding a relation between transmissibility and thickness I have made photographic exposures, in which the photographic plate was partly covered with a layer of tin foil consisting of a progressively increasing number of sheets. I shall make a photometric measurement when I am in possession of a suitable photometer.

5. Sheets were rolled from platinum, lead, zinc, and aluminum of such thickness that all appeared to be equally transmissible. The following table gives the measured thickness in millimeters, the relative thickness compared with platinum, and the specific gravity:

| | Thickness. | Relative Thickness. | Specific Gravity. |
|---|---|---|---|
| Platinum | 0.018 | 1 | 21.5 |
| Lead | 0.05 | 3 | 11.3 |
| Zinc | 0.10 | 6 | 7.1 |
| Aluminum | 3.5 | 200 | 2.6 |

From these values it may be seen that the transmissibility of plates of different metals so chosen that the product of the thickness and density is constant would not be equal. The transmissibility increases much faster than this product falls off.

6. The fluorescence of barium-platinum-cyanide is not the only action by which X-rays may be recognized. It should be remarked that they cause other substances to fluoresce, as for example the photophorescent calcium compounds, uranium glass, common glass, calcspar, rock salt, etc.

It is of particular importance from many points of view that photographic dry plates are sensitive to X-rays. It thus becomes possible to fix many phenomena so that deceptions are more easily avoided; and I have where practicable checked all important observations made with a fluorescent screen by photographic exposures.

It appears questionable whether the chemical action upon the silver salts of the photographic plate is produced directly by the X-rays. It is possible that this action depends upon the fluorescent light which, as is mentioned above, may be excited in the glass plate, or perhaps in the gelatine film. "Films" may indeed be made use of as well as glass plates.

I have not as yet obtained experimental evidence that the X-rays are capable of giving heat. This characteristic might, however, be assumed as present, since in the excitation of fluorescent phenomena the capacity

of the energy of the X-rays for transformation is proved, and since it is certain that of the X-rays falling upon a body not all are given up.

The retina of the eye is not sensitive to these rays. Nothing is to be noticed by bringing the eye near the vacuum tube, although according to the preceding observations the media of the eye must be sufficiently transmissible to the rays in question.

7. After I had discovered the transmissibility of various bodies of relatively great thickness I hastened to investigate whether or not the X-rays were refracted in passing through a prism. Experiments with water and carbon bisulphide in mica prisms of 30 degrees refracting angle showed no deviation either when observations were made with the fluorescent screen or with the photographic plate. For comparison, the deviation of light rays was observed under the same conditions. The refracted portion lay from 10 to 20 centimeters distant from that not refracted. With prisms of hard rubber and aluminum of about 30 degrees refracting angle I obtained exposures on a photographic plate which perhaps indicated a slight refraction. This is, however, very doubtful and the deviation is, if present, so small that the index of refraction for X-rays in these substances can not exceed 1.05. I could not observe with the fluorescent screen any deviation in these cases. Experiments with prisms of the denser metals have so far yielded no certain results on account of the slight transmissibility and the consequent decrease of the intensity of the transmitted ray.

In consideration of these results on the one hand, and on the other of the importance of the question whether or not the X-rays in passing from one medium to another undergo refraction, it is very gratifying that this question may be investigated by other means than by the help of prisms. Finely pulverized bodies in suitable layers allow but little light to pass, in consequence of refraction and reflection. If now the X-rays are transmitted equally well through powder as through the coherent substance, equal masses being presupposed, it is proved that neither refraction nor regular reflection is present in any marked degree. This experiment was performed using finely pulverized rock-salt, finely divided silver, obtained by electrolysis, and the zinc dust so frequently utilized in chemical processes. In no case was any difference in transmissibility between the powder and the coherent substance detected either by the use of the fluorescent screen or the photographic plate.

It follows of course from the results thus obtained that the X-rays can not be concentrated by the use of lenses; and, indeed, a great hard

rubber lens and a glass lens actually proved without effect. The shadow of a round rod is darker in the middle than at the edges, while that of a tube which is filled with some substance more transmissible than the material of which the tube is composed is darker at the edges than at the center.

8. The question as to the reflection of X-rays is so far settled by the experiments already described that no marked regular reflection was to be found with any of the substances examined. Other experiments which I will here pass over lead to the same results.

Nevertheless an observation should be mentioned which indicated at first glance an opposite result. A photographic plate shielded from the action of light rays by a black paper was exposed to X-rays so that the glass side was toward the discharge tube. The sensitive film was partially covered with bright plates of platinum, lead, zinc, and aluminum, arranged in a star-shaped figure. Upon development it was observed that the darkening of the film under the platinum, the lead, and especially the zinc was distinctly greater than in the other parts. No such effect was produced by the aluminum. Thus it seemed as if the three metals mentioned reflected. However, there were other causes to be conceived which might have produced the increased darkening, and in order to be sure I performed a second experiment, interposing a thin sheet of aluminum foil (very transmissible to X-rays, but not to those of the ultraviolet) between the metals and the sensitive film. Since in this case again practically the same result was obtained, the fact of reflection of X-rays by the metals above mentioned is established.

Taking this result together with the observation that powder is as transmissible as coherent substance, and further, that bodies with rough surfaces behave in the transmission of X-rays and also in the experiments just described exactly like polished bodies, the conclusion is reached that there is, as before remarked, no regular reflection, but that the bodies behave toward X-rays in the same manner as a turbid medium with reference to light.

As I have not been able to discover any refraction in the passage from one medium to another, it appears as if the X-rays travel with equal velocity in all bodies, and hence in a medium which is everywhere present and in which the particles of the bodies are embedded. These latter act as a hindrance to the propagation of the X-rays, which is in general greater the greater the density of the body in question.

9. In accordance with this supposition it might be possible that the

arrangement of the molecules of the body would exert an influence on its transmissibility, and that, for example, a piece of calcspar would be unequally transmissible for equal thicknesses when the rays passed along or at right angles to the axis. Experiments with calcspar and quartz gave, however, a negative result.

10. It will be recalled that Lenard, in his beautiful experiments on the transmission of the Hittorf cathode rays through thin aluminum foil, obtained the result that these rays are disturbances in the ether, and that they diffuse themselves in all bodies. We may make a similar statement with regard to our rays.

In his last research Lenard has determined the relative absorption of different substances for the cathode rays, and in determining the same for air at atmospheric pressure has given the values 4.10, 3.40, 3.10 as referred to 1 centimeter thickness according to the density of the gas in the discharge tube. Judging from the length of spark observed, I have, in my researches, generally employed tubes of about equal exhaustion and only seldom those of much greater or less density. Using the photometer of L. Weber, the best at my command, I compared the intensity of fluorescence on the screen in two positions distant 100 and 200 millimeters, respectively, from the discharge tube. From the results of these experiments, agreeing well with each other, it appeared that the intensity varies inversely as the square of the distance. Hence the air absorbs a much smaller portion of the X-rays passing through it than of cathode rays. This result is in accord with the observation above mentioned, that it is possible to distinguish fluorescence at 2 meters distance from the discharge tube.

Most other substances are, like the air, more transmissible for X-rays than for the cathode rays.

11. Another very noteworthy difference between the behavior of the cathode rays and the X-rays was exhibited in that I was unable to produce any deviation of the latter by the action of the most powerful magnetic fields. The property of being subject to deviation by magnets is, on the other hand, very characteristic of the cathode rays. Hertz and Lenard have observed various kinds of cathode rays which "are to be distinguished by their differences in their capacities for exciting phosphorescence in their absorbability and in theii deviation by the magnet," but a considerable magnetic deviation was to be observed with all of them, and I do not believe that this characteristic would be given up except for the most urgent reasons.

12. According to the results of experiments particularly directed to discover the source of the X-rays, it is certain that the part of the wall of the discharge tube which most strongly fluoresces is the principal starting point. The X-rays therefore radiate from the place where, according to various observers, the cathode rays meet the glass wall. If one diverts the cathode rays within the tube by a magnet, the source of the X-ray is also seen to change its position so that these radiations still proceed from the end points of the cathode rays. The X-rays being undeviated by magnets cannot, however, be simply cathode rays passing unchanged through the glass wall. The greater density of the gas outside of the discharge tube cannot, according to Lenard, be made answerable for the great difference of the deviation.

I come therefore to the results that the X-rays are not identical with the cathode rays, but that they are excited by the cathode rays in the glass wall of the vacuum tube.

13. This generating action takes place not only in glass, but as I observed it in apparatus with aluminum walls 2 millimeters thick, exists also for this metal. Other substances will be investigated.

14. The warrant for giving the title "rays" to the agent which proceeds from the wall of the discharge tube arose in part from the quite regular formation of shadows appearing when more or less transmissible substances are interposed between the generating apparatus and a phosphorescent screen or photographic plate. I have many times observed and sometimes photographed such shadow forms, in whose production there lies a particular charm. I have, for example, photographs of the shadow of the profile of a door which separates the two rooms, in one of which was the discharge apparatus, in the other the photographic plate; of the shadow of the hand bones; of the shadow of a wooden spool wound with wire; of a set of weights in a box; of a compass in which the magnetic needle is quite inclosed in metal; of a piece of metal which is shown to lack homogeneity by the use of X-rays, etc.

The propagation of the X-rays in right lines is shown by pin-hole photography, which I have been able to do with the discharge apparatus covered with black paper. The picture is weak, but unmistakably correct.

15. I have much sought to obtain interference phenomena with X-rays, but unfortunately—perhaps on account of their slight intensity—without result.

16. Experiments have been begun to see if electrostatic forces can in any way influence X-rays, but these are not yet finished.

17. If the question is asked what the X-rays—which certainly are not cathode rays—really are, one might at first, on account of their lively fluorescent and chemical action, compare them to ultra-violet light. But here one falls upon serious difficulties. Thus, if the X-rays were ultra-violet light, then this light must possess the following characteristics:

(*a*) That in passing from air into water, carbon bisulphide, aluminum, rock salt, glass, zinc, etc., it experiences no notable refraction.

(*b*) That it is not regularly reflected by these substances.

(*c*) That it cannot be polarized by the usual materials.

(*d*) That its absorption by substances is influenced by nothing so much as by their density.

In other words, one must assume that these ultra-violet radiations comport themselves quite differently from all previously known infra red, visible, and ultra-violet rays.

I have not been able to admit this, and have sought some other explanations.

A kind of relation seems to subsist between the new radiation and light radiation, or at least the shadow formation, the fluorescence, and the chemical action, which are common phenomena of these two kinds of radiation, point in this direction. It has been long known that longitudinal as well as transverse vibrations are possible in the ether, and according to various physicists must exist. To be sure, their existence has not, up to the present time, been proved, and hence their characteristics have not thus far been experimentally investigated.

Should not the new radiations be ascribed to longitudinal vibrations in the ether? I may say that in the course of the investigation this hypothesis has impressed itself more and more favorably with me, and I venture to propose it, although well aware that it requires much further examination.

WUERZBURG, PHYSIK. INSTITUT D. UNIV., *December, 1895.*

II.—UPON A NEW KIND OF RAYS (ABSTRACT.)

As my work must be interrupted for several weeks, I take the opportunity of presenting in the following some new results:

18. At the time of my first publication I was aware that the X-rays have the property of discharging electrified bodies, and I intimated that it was the X-rays and not the cathode rays passing unchanged through the aluminum window of his apparatus which produced the effect

described by Lenard on electrified bodies at a distance. I have, however, delayed publication of my experiments until I could present conclusive results.

These can be obtained only when the observations are carried on in a room which is not only completely insulated from the electrostatic forces emanating from the vacuum tube, the conducting wires, the induction apparatus, etc., but is also closed to the air which comes in the neighborhood of the discharge apparatus.

For this purpose I had a box constructed by soldering together zinc sheets, and this box was large enough to contain me and the necessary apparatus, and was air-tight with the exception of an opening which could be closed by a zinc door. The side opposite to the door was mostly lined with lead, and immediately adjacent to the discharge tube an opening 4 centimeters wide was cut in the lead and zinc wall, and its place filled up air-tight with aluminum foil. Through this window passed the X-rays to be investigated. I have with this apparatus verified the following results:

(*a*) Positively or negatively electrified bodies placed in air are discharged when immersed in X-rays, and the action is the more rapid the more intense the radiations. The intensity of the rays is determined by their action upon a fluorescent screen or a photographic plate.

It is in general immaterial whether the electrified substance is a conductor or non-conductor. Thus far I have discovered no difference in the behavior of different bodies relative to the rapidity of their discharge, or between positive or negative charges. These points are, however, open to further investigation.

(*b*) When an electrified conductor is surrounded by a solid insulator, as for example, paraffine, the radiation produces the same effect as would the flashing of the insulating shell by a flame placed in contact with the ground.

(*c*) If this insulator be in its turn closely surrounded by a grounded conductor and both itself and this outer conductor be transmissible to X-rays, the action of the X-radiations upon the inner conductor is unnoticeable with the apparatus at my command.

(*d*) The observations recorded under (*a*), (*b*), and (*c*) indicate that the air through which X-rays pass possesses the property of discharging any electrified bodies with which it comes in contact.

(*e*) If this be indeed the case, and if the air retains for some considerable time this property imparted to it by the X-rays, it must be pos-

sible to discharge electrified bodies not themselves under the influence of X-rays by bringing to them air which has been subject to these radiations.

One may satisfy himself in various ways that this is the case. The following, though perhaps not the simplest method, may be mentioned:

I employed a brass tube 3 centimeters wide and 45 centimeters long. At 1 centimeter's distance from one end a portion of the tube was cut away and replaced by a thin sheet of aluminum. At the other end there was introduced a brass ball, which was supported by a metal support, and this end was closed air-tight. Between the brass ball and the closed end of the tube a side tube was soldered in, which was connected with an air-pump. By this means a current of air was made to flow by the brass ball, after having passed the aluminum window. The distance from the ball to the window was 20 centimeters.

I mounted this tube in the zinc box in such a manner that the X-rays entered the tube at right angles to its axis, and the insulated ball lay outside the reach of these rays, in the shadow. The tube and zinc box were placed in contact and the ball was connected with a Hankel electroscope.

It was shown that a charge on the ball, whether positive or negative, was not influenced by X-rays so long as the air remained quiet in the tube, but that a marked diminution of the charge was produced by sucking a strong current of air through. If the ball was kept at constant potential by connecting it with accumulators, and a continuous current of air was kept flowing in the tube, an electrical current was set up just as if the ball was connected with the walls of the tube by a conductor of high resistance. * * *

20. In section 13 of my first article it was stated that the X-rays may be generated not only in glass but in aluminum. In conducting experiments in this direction no solid bodies were found which were not capable of producing X-rays when under the influence of cathode rays. I know no reason to suppose that liquids and gases also do not act similarly.

Different substances, however, possess this property in different degrees. For example, if cathode rays are caused to fall upon a plate of which one-half is composed of platinum foil 0.3 millimeter thick and the other half of aluminum 1 millimeter thick, one may observe in the photographic image taken with the pinhole camera that the platinum foil sends out many more X-rays from the side bombarded by the

cathode rays than does the aluminum on the same side. But from the back side of the plate there go out almost no X-rays from the platinum, while the aluminum sends out a relatively large number. These latter rays are generated at the front layers of the aluminum and pass through the plate.

It should be remarked that these observations have a practical significance. For the generation of X-rays of the greatest possible intensity my experience recommends the employment of platinum. I have used for some weeks with advantage a discharge apparatus having a concave mirror of aluminum as cathode, and as annode a platinum plate placed in the center of curvature, and at an angle of 45 degrees with the axis.

21. The X-rays proceed from the annode with this apparatus. As I have concluded from experiments with apparatus of various forms, it is immaterial with regard to the intensity of the X-rays whether they proceed from the annode or not. * * *

(WUERZBURG, PHYSIK. INSTITUT D. UNIVERSITAET, *March 9, 1896.*)

III.—FURTHER OBSERVATIONS ON THE PROPERTIES OF X-RAYS (EXTRACT).

With reference to practical applications, the observation of the distribution of intensity of the rays proceeding from the platinum plate has some value in connection with the formation of shadow pictures by means of X-rays. In accordance with the observations above recorded it is to be recommended that the discharge tube be so arranged that the rays employed for formation of pictures be those making a large angle, though not much exceeding 80 degrees, with the platinum plate. In this way the sharpest possible delineation will be obtained, and if the platinum plate is flat and the construction of the tube such that the rays proceeding obliquely pass through not much greater thickness of glass than those going out at right angles to the platinum plate, then no material loss in intensity will be experienced in this arrangement.

5. If two plates of different substances are equally transmissible this equality will not in general be retained for another pair of plates of the same substances with thicknesses altered in the same ratio. This fact may be shown very easily by the use of thin sheets, as, for example, of platinum and aluminum. I used for this purpose platinum foil 0.0026 millimeter thick and aluminum foil 0.0299 millimeter thick. I found in one instance that one sheet of platinum was equally transmissible with

six sheets of aluminum; but the transmissibility of two sheets of platinum was less than that of twelve sheets of aluminum and about equal to that of sixteen sheets of the latter metal. Using another discharge tube, I found 1 platinum equal 8 aluminum, but 8 platinum equal 90 aluminum. From these experiments it follows that the ratio of thicknesses of platinum and aluminum of equal transmissibility is less the thicker the sheets under examination.

6. The ratio of the thicknesses of two equally transmissible plates of different material is dependent on the thickness and the material of the body, as, for instance, the glass wall of the discharge tube, through which the rays have to pass before they reach the plates investigated.

* * *

7. The experiments described in sections 4, 5, and 6 relate to the alterations which the X-rays proceeding from a discharge tube experience in their transmission through different substances. It will now be shown that one and the same body may for the same thickness be unequally transmissible for rays emitted from different discharge tubes.

In the following table are given the values of the transmissibility of an aluminum plate 2 millimeters thick for the rays given out by different tubes:

| | Tube. | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 2 | 5 |
| Transmissibility for vertically incident rays of a 2-millimeter thick aluminum plate.......... | 0.0044 | 0.22 | 0.30 | 0.39 | 0.50 | 0.59 |

The discharge tubes were not materially different in their construction or in the thickness of their glass wall, but varied in the density of the gas within them, and hence in the potential required to produce discharge. Tube 1 required the least and tube 5 the greatest potential, or, as we may say for short, the tube 1 is the "softest" and tube 5 the "hardest." The same Ruhmkorff in direct connection with the tubes, the same circuit breaker, and the same current strength in the primary circuit were used in all cases.

Various other substances which I have investigated behaved similarly to aluminum. All are more transmissible to rays from harder tubes. This fact seemed to me particularly worthy of attention.

The relative transmissibility of plates of different substances proved also to be dependent on the hardness of the discharge tube employed. The ratio of the thickness of platinum and aluminum plates of equal

transmissibility becomes less the harder the tubes from which the rays proceed, or, referring to the results just given, the less the rays are absorbed.

The different behavior of rays excited in tubes of different hardness is also made apparent in the well known shadow picturing of hands, etc. With a soft tube a dark shadow is obtained, in which the bones are little prominent; when a harder tube is used the bones are very distinct and visible in all their details, whereas the softer portions are less marked. and with very hard tubes even the bones themselves become only weak shadows. From these considerations it appears that the choice of the tube must be governed by the character of the objects which it is desired to portray.

It remains to remark that the quality of rays proceeding from one and the same tube depends on various conditions. Of these the most important are the following: (1) The action of the interrupter, or, in other words, the course of the primary current. In this connection should be mentioned the phenomena frequently observed that particular ones of the rapidly succeeding discharges excite X-rays which are not only more intense, but which also differ from the others in their absorption. (2) The character of the sparks which appear in the secondary circuit of the apparatus. (3) The employment of a Tesla transformer. (4) The degree of evacuation of the discharge tube (as already stated). (5) The varying, but as yet not satisfactorily known, procedure within the discharge tube. Separate ones among these conditions require further comment. * * *

The hardness of a tube had been considered to be brought about solely by the continuation of the evacuation by means of the pump; but this characteristic is affected in other ways. Thus a sealed tube of medium hardness becomes gradually harder by itself—unfortunately to the shortening of the period of its usefulness when used in a suitable manner for the production of X-rays, that is to say, when discharges which do not cause the platinum to glow or at least to glow only weakly are passed through. A gradual self-evacuation is thus effected.

With a tube thus become very hard I took a very fine photograph of a double-barreled gun with inserted cartridges, which showed all the details of the cartridges, the inner faults of the Damascus barrels, etc., very sharply and distinctly. The distance from the platinum plate of the discharge tube to the photographic plate was 15 centimeters and the exposure twelve minutes—comparatively long in consequence of the small photographic action of the very slightly absorbable rays (see

below). The Duprez interrupter had to be replaced by the Foucault form. It would be of interest to construct tubes which would make it possible to use still higher potentials than before.

Self-evacuation has been above assigned as the cause of the growing hardness of sealed tubes, but this is not the only cause. There are changes in the electrodes which produce this effect. I do not know the nature of these changes. * * *

The observations recorded in these paragraphs and others not given have led me to the view that the composition of the rays proceeding from a platinum anode of a discharge tube depends upon the frequency and form of the discharge current. The degree of tenuity, the hardness, is important only because the form of the discharge is thereby influenced. If it were possible to produce the proper form of discharge for the generation of X-rays in any other way, the X-rays might be obtained with relatively high pressures.

9. The results appearing in the five preceding paragraphs have been those most evidently to be derived from the accompanying experiments. Summing up these separate results, and being guided in part by and X-rays, one arrives at the following conclusions:

(*a*) The radiations emitted by a discharge tube consist of a mixture of rays of different absorbability and intensity.

(*b*) The composition of this mixture is in a marked degree dependent on the frequency and form of the discharge current.

(*c*) The rays receiving preference in absorption vary with different bodies.

(*d*) Since the X-rays are generated by the cathode rays and have in common with them various characteristics—as the exciting of fluorescence, photographic and electrical actions, an absorbability depending in a marked degree on the density of the medium traversed, etc.—the conjecture is prompted that both phenomena are processes of the same nature. Without committing myself unconditionally to this view, I may remark that the results of the last paragraphs are calculated to raise a difficulty in the way of this hypothesis. This difficulty consists in the great difference between the absorption of the cathode rays investigated by Lenard and the X-rays, and second, that the transmissibility of bodies for the cathode rays is related to their density by other laws than those which govern their transmissibility for X-rays.

With regard to the first point, considerations present themselves under two heads: (1) As we have seen in section 7, there are X-rays of

different absorbability, and the investigations of Hertz and Lenard show that the cathode rays are similarly to be discriminated. While the "softest" tubes investigated generated rays much less subject to absorption than any cathode rays investigated by Lenard, yet there is no reason to doubt the possibility of X-rays of greater absorbability, and cathode rays of less. It therefore appears probable that in future investigations rays will be found bridging over the gap between X-rays and cathode rays, so far as their absorption is concerned. (2) We found in section 4 that the specific transmissibility of a body becomes less the thinner the plate passed through. Consequently, had we made use in our experiments of plates as thin as those employed by Lenard it would have been found that the X-rays were more nearly like those of Lenard in their absorbability.

10. Besides the fluorescent phenomena, there may be excited by X-rays photographic, electric, and other actions, and it is of interest to know how far these various manifestations vary in similar ratio when the source of the rays is altered. I must restrict myself to a comparison of the first two phenomena. * * *

A hard and a soft tube were so adjusted as to give equally bright fluorescence as compared by means of the photometer described in section 2. Upon substituting a photographic plate in the place of the fluorescent screen it was found, on development, that the portion subject to the rays from the hard tube was blackened to a less degree than the other. The rays, though producing equal fluorescence, were thus for photographic purposes unequally active. * * *

The great sensitiveness of a photographic plate even for rays from tubes of medium hardness is illustrated by an experiment in which 96 films were superposed, placed at a distance of 25 centimeters from the discharge tube, and exposed five minutes with due precautions to protect the films from the radiations of the air. A photographic action was apparent on the last film, although the first was scarcely over-exposed. * * *

If the intensity of the radiations is augmented by increasing the strength of the primary current, the photographic action increases in the same measure as the intensity of the fluorescence. In this case, as in the case where the intensity of the radiation was increased by an alteration of the distance of the fluorescent screen, the brightness of the fluorescence is at least approximately proportional to the intensity of the radiation. This rule should not, however, be too generally applied.

11. In conclusion, mention should be made of the following particulars:

With a discharge tube of proper construction, and not too soft, the X-rays are chiefly generated in a spot of not more than 1 or 2 millimeters diameter where the cathode rays meet the platinum plate. This, however, is not the sole source. The whole plate and a part of the tube walls emit X-rays, though in less intensity. Cathode rays proceed in all directions, but their intensity is considerable only near the axis of the concave cathode mirror, and, consequently, the X-rays are strongly emitted only near the point where this axis meets the platinum plate. When the tube is very hard and the platinum thin, many rays proceed also from the rear surface of the platinum plate, but, as may be shown by the pinhole camera, chiefly from the spot lying on the axis of the mirror. * * *

I can confirm the observation of G. Brandes that the X-rays are able to produce a sensation of light upon the retina of the eye. In my record book appears a notice entered in the early part of November, 1895, to the effect that when in a darkened chamber, near a wooden door, I perceived a weak appearance of light when a Hittorf tube upon the other side of the door was put in operation. Since this appearance was only once observed, I regarded it as a subjective, and the reason that it was not then repeatedly observed lay in the fact that other tubes were substituted for the Hittorf tube which were less completely evacuated and not provided with platinum anodes. The Hittorf tube furnishes rays of slight absorbability on account of its high vacuum, and, at the same time, of great intensity on account of the employment of a platinum anode for the reception of the cathode rays. * * *

With the tubes now in use I can easily repeat the Brandes experiment. * * *

Since the beginning of my investigation of X-rays I have repeatedly endeavored to produce diffraction phenomena with them. I obtained at various times, when using narrow slits, appearances similar to diffraction effects, but when modifications were made in the conditions for the purpose of thoroughly proving the accuracy of this explanation of the phenomena it was found in each case that the appearances were produced in other ways than by diffraction. I know of no experiment which gives satisfactory evidence of the existence of diffraction with the X-rays.

# W. H. PREECE

William Marconi was born near Bologna, Italy, in 1875. He became an electrical engineer and early gave his attention to the transmission of the Hertz electric waves without wires. The description given below is by W. H. Preece, who invented a system which proved successful over short distances some years before Marconi.

## WIRELESS TELEGRAPHY: THE PREECE AND MARCONI SYSTEMS

Science has conferred one great benefit on mankind. It has supplied us with a new sense. We can now see the invisible, hear the inaudible, and feel the intangible. We know that the universe is filled with a homogeneous continuous elastic medium which transmits heat, light, electricity and other forms of energy from one point of space to another without loss. The discovery of the real existence of this "ether" is one of the great scientific events of the Victorian era. Its character and mechanism are not yet known to us. All attempts to "invent" a perfect ether have proved beyond the mental powers of the highest intellects. We can only say with Lord Salisbury that the ether is the nominative case of the verb "to undulate." We must be content with a knowledge of the fact that it was created in the beginning for the transmission of energy in all its forms, that it transmits these energies in definite waves and with a known velocity, that it is perfect of its kind, but that it still remains as inscrutable as gravity or light itself.

Any disturbance of the ether must originate with some disturbance of matter. An explosion, cyclone, or vibratory motion may occur in the photosphere of the sun. A disturbance or wave is impressed on the ether. It is propagated in straight lines through space. It falls on Jupiter, Venus, the Earth, and every other planet met with in its course, and any machine, human or mechanical, capable of responding to its undulations indicates its presence. Thus the eye supplies the sensation

# MARCONI

of light, the skin is sensitive to heat, the galvanometer indicates electricity, the magnetometer indicates disturbances in the earth's magnetic field. One of the greatest scientific achievements of our generation is the magnificent generalization of Clerk-Maxwell that all these disturbances are of precisely the same kind, and that they differ only in degree. Light is an electromagnetic phenomenon, and electricity in its progress through space follows the laws of optics. Hertz proved this experimentally, and few of us who heard it will forget the admirable lecture on "The Work of Hertz" given in this hall by Prof. Oliver Lodge three years ago.

By the kindness of Prof. Silvanus Thompson I am able to illustrate wave transmission by a very beautiful apparatus devised by him. At one end we have the transmitter or oscillator, which is a heavy suspended mass to which a blow or impulse is given, and which, in consequence, vibrates a given number of times per minute. At the other end is the receiver or resonator, timed to vibrate to the same period. Connecting the two together is a row of leaden balls suspended so that each ball gives a portion of its energy at each oscillation to the next in the series. Each ball vibrates at right angles to or athwart the line of propagation of the wave, and as they vibrate in different phases you will see that a wave is transmitted from the transmitter to the receiver. The receiver takes up these vibrations and responds in sympathy with the transmitter. Here we have a visible illustration of that which is absolutely invisible. The wave you see differs from a wave of light or of electricity only in its length or in its frequency. Electric waves vary from units per second in long submarine cables to millions per second when excited by Hertz's method. Light waves vary per second between 400 billions in the red to 800 billions in the violet, and electric waves differ from them in no other respect. They are reflected, refracted and polarized, they are subject to interference, and they move through the ether in straight lines with the same velocity, viz, 186,400 miles per second—a number easily recalled when we remember that it was in the year 1864 that Maxwell made his famous discovery of the identity of light and electric waves.

Electric waves, however, differ from light waves in this, that we have also to regard the direction at right angles to the line of propagation of the wave. The model gives an illustration of that which happens along a line of electric force; the other line of motion I speak of is a circle around the point of disturbance, and these lines are called lines

of magnetic force. The animal eye is tuned to one series of wave; the "electric eye," as Lord Kelvin called Hertz's resonator, to another. If electric waves could be reduced in length to the forty-thousandth of an inch we should see them as colors.

One more definition, and our ground is cleared. When electricity is found stored up in a potential state in the molecules of a dielectric like air, glass, or gutta-percha the molecules are strained, it is called a charge, and it establishes in its neighborhood an electric field. When it is active, or in its kinetic state in a circuit, it is called a current. It is found in both states—kinetic and potential—when a current is maintained in a conductor. The surrounding neighborhood is then found in a state of stress, forming what is called a magnetic field.

In the first case the charges can be made to rise and fall, and to surge to and fro with rhythmic regularity, exciting electric waves along each line of electric force at very high frequencies, and in the second case the currents can rise or alternate in direction with the same regularity, but with very different frequencies, and originate electromagnetic waves whose wave fronts are propagated in the same direction.

The first is the method of Hertz, which has recently been turned to practical account by Mr. Marconi, and the second is the method which I have been applying, and which, for historical reasons, I will describe to you first.

In 1884 messages sent through insulated wires buried in iron pipes in the streets of London were read upon telephone circuits erected on poles above the house tops, 80 feet away. Ordinary telegraph circuits were found in 1885 to produce disturbances 2,000 feet away. Distinct speech by telephone was carried on through one-quarter of a mile, a distance that was increased to 1½ miles at a later date. Careful experiments were made in 1886 and 1887 to prove that these effects were due to pure electromagnetic waves, and were entirely free from any earth-conduction. In 1892 distinct messages were sent across a portion of the Bristol Channel, between Penarth and Flat Holm, a distance of 3.3 miles.

Early in 1895 the cable between Oban and the Isle of Mull broke down, and as no ship was available for repairing and restoring communication, communication was established by utilizing parallel wires on each side of the channel and transmitting signals across the space by these electromagnetic waves.

The apparatus (fig. 1) connected to each wire consists of—

(*a*) A rheotome or make and break wheel, causing about 260 undulations per second in the primary wire.

(*b*) An ordinary battery of about 100 Leclanché cells, of the so-called dry and portable form.

(*c*) A Morse telegraph key.

(*d*) A telephone to act as receiver.

(*e*) A switch to start and stop the rheotome.

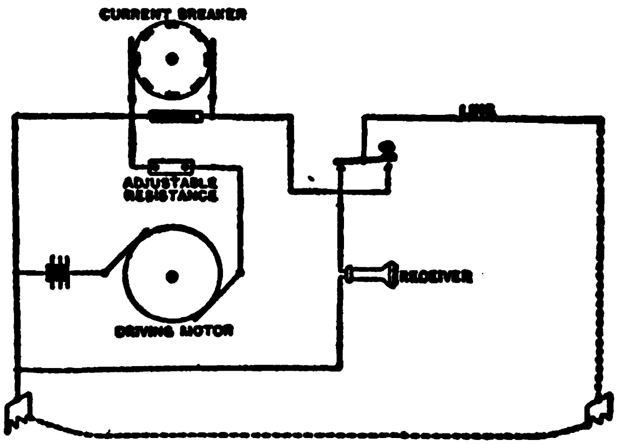



FIG. 1. Diagram of connections of Mr. Preece's system.

Good signals depend more on the rapid rise and fall of the primary current than on the amount of energy thrown into vibration. Leclanché cells gave as good signals at 3.3 miles distant as 2½ horse-power transformed into alternating currents by an alternator, owing to the smooth sinusoidal curves of the latter. Two hundred and sixty vibrations per second give a pleasant note to the ear, easily read when broken up by the key into dots and dashes.

In my electromagnetic system two parallel circuits are established, one on each side of a channel or bank of a river, each circuit becoming successively the primary and secondary of an induction system, according to the direction in which the signals are being sent. Strong alternating or vibrating currents of electricity are transmitted in the first circuit so as to form signals, letters, and words in Morse character. The effects of the rise and fall of these currents are transmitted as electro-

magnetic waves through the intervening space, and if the secondary circuit is so situated as to be washed by these ethereal waves, their energy is transformed into secondary currents in the second circuit, which can be made to affect a telephone and thus to reproduce the signals. Of course their intensity is much reduced, but still their presence has been detected, though five miles of clear space have separated the two circuits.

Such effects have been known scientifically in the laboratory since the days of Faraday and of Henry, but it is only within the last few years that I have been able to utilize them practically through considerable distances. This has been rendered possible through the introduction of the telephone.

Last year (August, 1896) an effort was made to establish communication with the North Sandhead (Goodwin) lightship. The apparatus used was designed and manufactured by Messrs. Evershed and Vignoles, and a most ingenious relay to establish a call invented by Mr. Evershed. One extremity of the cable was coiled in a ring on the bottom of the sea, embracing the whole area over which the lightship swept while swinging to the tide, and the other end was connected with the shore. The ship was surrounded above the water line with another coil. The two coils were separated by a mean distance of about 200 fathoms, but communication was found to be impracticable. The screening effect of the sea water and the effect of the iron hull of the ship absorbed practically all the energy of the currents in the coiled cable, and the effects on board, though perceptible, were very trifling—too minute for signaling. Previous experiments had failed to show the extremely rapid rate at which energy is absorbed with the depth or thickness of sea water. The energy is absorbed in forming eddy currents. There is no difficulty whatever in signaling through 15 fathoms. Speech by telephone has been maintained through 6 fathoms. Although this experiment has failed through water, it is thoroughly practical through air to considerable distances where it is possible to erect wires of similar length to the distance to be crossed on each side of the channel. It is not always possible, however, to do this, nor to get the requisite height to secure the best effect. It is impossible on a lightship and on rock lighthouses. There are many small islands—Sark, for example—where it cannot be done.

In July last Mr. Marconi brought to England a new plan. My plan is based entirely on utilizing electromagnetic waves of very low frequency. It depends essentially on the rise and fall of currents in the primary wire. Mr. Marconi utilizes electric or Hertzian waves of very high frequency, and they depend upon the rise and fall of electric force in a sphere or spheres. He has invented a new relay which, for sensitiveness and delicacy, exceeds all known electric apparatus.

The peculiarity of Mr. Marconi's system is that, apart from the ordinary connecting wires of the apparatus, conductors of very moderate length only are needed, and even these can be dispensed with if reflectors are used.

*The transmitter.*—His transmitter is Professor Righi's form of Hertz radiator (fig. 2).

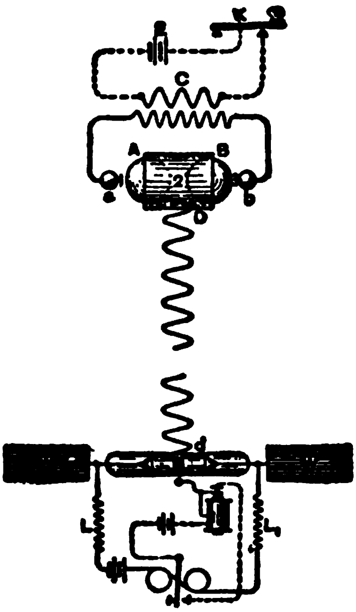



FIG. 2. Diagram of the Marconi apparatus.

Two spheres of solid brass, 4 inches in diameter (A and B), are fixed in an oil-tight case D of insulating material, so that a hemisphere of each is exposed, the other hemisphere being immersed in a bath of vaseline oil. The use of oil has several advantages. It maintains the surfaces of the spheres electrically clean, avoiding the frequent polishing required by Hertz's exposed balls. It impresses on the waves excited by these spheres a uniform and constant form. It tends to reduce the wave lengths—Righi's waves are measured in centimeters, while Hertz's were measured in meters. For these reasons the distance at which effects are produced is increased. Mr. Marconi uses generally waves of about 120 centimeters long. Two small spheres, *a* and *b*, are fixed close to the large spheres, and connected each to one end of the secondary circuit of the "induction coil" C, the primary circuit of which is excited by a battery E, thrown in and out of circuit by the Morse key K. Now, whenever the key K is depressed sparks pass between 1, 2, and 3, and since the system A B contains capacity and electric inertia, oscillations are set up in it of extreme rapidity. The line

of propagation is D *d*, and the frequency of oscillation is probably about 250 millions per second.

The distance at which effects are produced with such rapid oscillations depends chiefly on the energy in the discharge that passes. A 6-inch spark coil has sufficed through 1, 2, 3, up to 4 miles, but for greater distances we have used a more powerful coil—one emitting sparks 20 inches long. It may also be pointed out that this distance increases with the diameter of the spheres A and B, and it is nearly doubled by making the spheres solid instead of hollow.

*The receiver.*—Marconi's relay (fig. 2) consists of a small glass tube 4 centimeters long, into which two silver pole pieces are tightly fitted, separated from each other by about half a millimeter—a thin space which is filled up by a mixture of fine nickel and silver filings, mixed with a trace of mercury. The tube is exhausted to a vacuum of 4 millimeters, and sealed. It forms part of a circuit containing a local cell and a sensitive telegraph relay. In its normal condition the metallic powder is virtually an insulator. The particles lie higgledy-piggledy, anyhow, in disorder. They lightly touch each other in an irregular method, but when electric waves fall upon them they are "polarized," order is installed. They are marshaled in serried ranks, they are subject to pressure—in fact, as Prof. Oliver Lodge expresses it, they "cohere"—electrical contact ensues and a current passes. The resistance of such a space falls from infinity to about 5 ohms. The electric resistance of Marconi's relay—that is, the resistance of the thin disc of loose powder—is practically infinite when it is in its normal or disordered condition. It is then, in fact, an insulator. This resistance drops sometimes to 5 ohms, when the absorption of the electric waves by it is intense. It therefore becomes a conductor. It may be, as suggested by Professor Lodge, that we have in the measurement of the variable resistance of this instrument a means of determining the intensity of the energy falling upon it. This variation is being investigated both as regards the magnitude of the energy and the frequency of the incident waves. Now such electrical effects are well known. In 1866 Mr. S. A. Varley introduced a lightning protector constructed like the above tube, but made of boxwood and containing powdered carbon. It was fixed as a shunt to the instrument to be protected. It acted well, but it was subject to this coherence, which rendered the cure more troublesome than the disease, and its use had to be abandoned. The same action is very common in granulated carbon microphones like

Hunning's, and shaking has to be resorted to to decohere the carbon particles to their normal state. M. E. Branly (1890) showed the effect with copper, aluminum, and iron filings. Prof. Oliver Lodge, who has done more than anyone else in England to illustrate and popularize the work of Hertz and his followers, has given the name "coherer" to this form of apparatus. Marconi "decoheres" by making the local current very rapidly vibrate a small hammer head against the glass tube, which it does effectually, and in doing so makes such a sound that reading Morse characters is easy. The same current that decoheres can also record Morse signals on paper by ink. The exhausted tube has two wings which, by their size, tune the receiver to the transmitter by

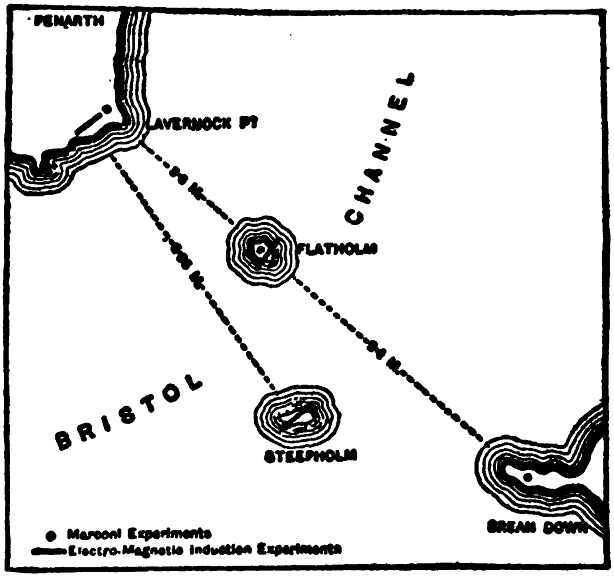



FIG. 3. Map of locality where the experiments were carried out.

varying the capacity of the apparatus. Choking coils prevent the energy escaping. The analogy to Prof. Silvanus Thompson's wave apparatus is evident. Oscillations set up in the transmitter fall upon the receiver tuned in sympathy with it, coherence follows, currents are excited, and signals made.

In open clear spaces within sight of each other nothing more is wanted, but when obstacles intervene and great distances are in question, height is needed—tall masts, kites, and balloons have been used. Excellent signals have been transmitted between Penarth and Brean Down, near Weston-super-Mare, across the Bristol Channel, a distance

of nearly 9 miles (fig. 3). (The system was here shown in operation.)

Mirrors also assist and intensify the effects. They were used in the earlier experiments, but they have been laid aside for the present, for they are not only expensive to make, but they occupy much time in manufacture.

It is curious that hills and apparent obstructions fail to obstruct. The reason is probably the fact that the lines of force escape these hills. When the ether is entangled in matter of different degrees of inductivity, the lines are curved, as in fact they are in light. Figure 4 shows how a hill is virtually bridged over by these lines, and conquently some electric waves fall on the relay. Weather seems to have no influence; rain, fogs, snow, and wind avail nothing.

FIG. 4. Diagram illustrating the way in which hills are bridged by the electric waves.

The wings shown in figure 2 may be removed. One pole can be connected with earth, and the other extended up to the top of the mast, or fastened to a balloon by means of a wire. The wire and balloon or kite, covered with tin foil, becomes the wing. In this case one pole of the transmitter must also be connected with earth. This is shown in figure 5.

There are some apparent anomalies that have developed themselves during the experiments. Mr. Marconi finds that his relay acts even when it is placed in a perfectly c l o s e d metallic box. This is the fact that has given rise to the rumor that he can blow up an ironclad ship. This might be true if he could plant his properly tuned receiver in the magazine of an enemy's ship. Many other funny things could be done if this were possible. I remember in my childhood that Captain Warner blew up a ship

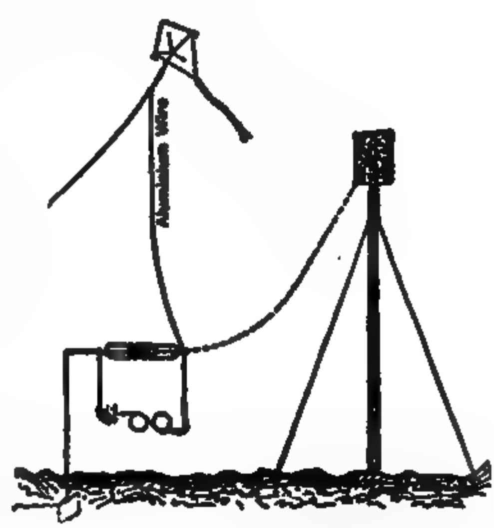


FIG. 5. Diagram of Marconi connections when using pole or kite.

at a great distance off Brighton. How this was done was never known, for his secret died shortly afterwards with him. It certainly was not by means of Marconi's relay.

The distance to which signals have been sent is remarkable. On Salisbury Plain Mr. Marconi covered a distance of 4 miles. In the Bristol Channel this has been extended to over 8 miles, and we have by no means reached the limit. It is interesting to read the surmises of others. Half a mile was the wildest dream.

It is easy to transmit many messages in any direction at the same time. It is only necessary to tune the transmitters and receivers to the same frequency or "note." I could show this here, but we are bothered by reflection from the walls. This does not happen in open space. Tuning is very easy. It is simply necessary to vary the capacity of the receiver, and this is done by increasing the length of the wings W in figure 2. The proper length is found experimentally close to the transmitter. It is practically impossible to do so far away.

It has been said that Mr. Marconi has done nothing new. He has not discovered any new rays; his transmitter is comparatively old; his receiver is based on Branly's coherer. Columbus did not invent the egg, but he showed how to make it stand on its end, and Marconi has produced from known means a new electric eye, more delicate than any known electrical instrument, and a new system of telegraphy that will reach places hitherto inaccessible. There are a great many practical points connected with this system that require to be threshed out in a practical manner before it can be placed on the market, but enough has been done to prove its value, and to show that for shipping and light-house purposes it will be a great and valuable acquisition.

# CHEMISTRY

In 1864 NEWLANDS of London and Lothar Meyer of Germany found that if many of the elements were arranged in order of their atomic weights, certain resemblances in their qualities were noticeable between an element and the eighth from it. This became known as the theory of chemical octaves. In 1869 Mendeléef made out a new list, reconsidered the resemblances, and left blanks here and there to be filled in with elements still to be discovered. Now the most striking proof of the theory is that elements have actually been discovered answering the description given them and with the proper atomic weights. In his table the elements, arranged in order of their atomic weights, fall naturally into families. The great significance of this theory is that the elements are not wholly independent, but would seem themselves to be compound, with qualities depending on their atomic weights. The large number of new elements recently discovered all find a more or less satisfactory place in the periodic table.

Another conception that is having great influence is that of the charged atom or "ion." Putting together the observations of a number of chemists, von t'Hoff has announced the law that if a substance is dissolved in a large quantity of the solvent the molecules are so far separated as to act as in a gas. Thus they exert pressure on the interior walls of the receptacle. Exceptions to this rule he showed to take place when the atoms of the molecules are electrically dissociated, that is, become charged atoms or "ions." A solution of potassium nitrate is such a charged solution. If an electric current is sent through it, the minus atoms of potassium are attracted to the plus pole, the plus atoms of

nitrate N O3 are drawn to the minus pole. Both sets of atoms are discharged. They then become free to act on the water of the solution. The potassium combines with the oxygen of the water and liberates hydrogen; the N O3 groups combine with the hydrogen of the water and liberate oxygen. This is in general the best explanation of the method of electrolysis.

Doctor Jaques Loeb has shown that such charged salt atoms cause muscular vibrations. A heart will begin beating if placed in such a solution. The electric charge contained by such atoms in solution seems to be enormous. Their influence on life is still a question of study. Dr. Loeb thinks he has been able to start a growth in the unfertilized eggs of sea urchins. It may be, however, that a cross is not always needed between such eggs. Some poisons are shown to contain strong minus ions. Food may even be needed more for its ions than the heat it contains. It is conceivable that a nerve impulse is based on the same principle. The nerves consist of phosphorized fat in a weak salt solution. They are "colloid" substances, that is, they do not crystallize when they solidify. The nerve impulse may be some sort of precipitation along the nerve, each colloid releasing some minus charged ions which precipitate the next colloid. The last minus ions act on and contract the muscle. But this is still in the domain of unproved theory.

Equally unproved is Lord Kelvin's theory that the atom is a whirling ring in the ether, comparable to a ring of smoke in the air. Such a ring would account for many qualities of the atoms, such as indestructibility, but, as Lord Kelvin himself has said, the hypothesis is as yet only a dream.

## D. I. MENDELEEF

Dmitri Ivanovich Mendeleef was born at Tobolsk, Russia, in 1834. He was made professor of chemistry in St. Petersburg in 1866. In 1869 he took up the question of Newland's law of octaves in chemistry and announced his great law of the periodicity of the elements. This is in brief that the qualities of the elements bear a close relation to their atomic weights. If the elements are arranged in a series

according to their atomic weights, the list seems naturally to break into families of related elements. This enabled Mendeléef to correct many of the atomic weights then accepted, and, what is most convincing, to describe closely hitherto undiscovered elements needed to fill out certain families, which afterward turned up with qualities tallying wonderfully with his descriptions.

## THE PERIODIC LAW OF THE CHEMICAL ELEMENTS

The high honour bestowed by the Chemical Society in inviting me to pay a tribute to the world-famed name of Faraday by delivering this lecture has induced me to take for its subject the Periodic Law of the Elements—this being a generalization in chemistry which has of late attracted much attention.

While science is pursuing a steady and onward movement, it is convenient from time to time to cast a glance back on the route already traversed, and especially to consider the new conceptions which aim at discovering the general meaning of the stock of facts accumulated from day to day in our laboratories. Owing to the possession of laboratories, modern science now bears a new character, quite unknown, not only to antiquity, but even to the preceding century. Bacon's and Descartes' idea of submitting the mechanism of science simultaneously to experiment and reasoning has been fully realized in the case of chemistry, it having not only been possible but always customary to experiment. Under the all-penetrating control of experiment, a new theory, even if crude, is quickly strengthened, provided it be founded on a sufficient basis; the asperities are removed, it is amended by degrees, and soon loses the phantom light of a shadowy form or of one founded on mere prejudice; it is able to lead to logical conclusions, and to submit to experimental proof. Willingly or not, in science we all must submit not to do what seems to us attractive from one point of view or from another, but to what represents an agreement between theory and experiment. Is it long since many refused to accept the generalizations involved in the law of Avogadro and Ampère, so widely extended by Gerhardt? We still may hear the voices of its opponents; they enjoy perfect freedom, but vainly will their voices rise so long as they do not use the language of demonstrated facts. The striking observations with the spectroscope which have permitted us to analyze the chemical constitu-

tion of distant worlds, seemed at first applicable to the task of determining the nature of the atoms themselves; but the working out of the idea in the laboratory soon demonstrated that the characters of spectra are determined, not directly by the atoms, but by the molecules into which the atoms are packed; and so it became evident that more verified facts must be collected before it will be possible to formulate new generalizations capable of taking their place beside those ordinary ones based upon the conception of simple substances and atoms. But as the shade of the leaves and roots of living plants, together with the relics of a decayed vegetation, favour the growth of the seedling and serve to promote its luxurious development, in like manner sound generalizations—together with the relics of those which have proved to be untenable—promote scientific productivity, and insure the luxurious growth of science under the influence of rays emanating from the centers of scientific energy. Such centers are scientific associations and societies. Before one of the oldest and most powerful of these I am about to take the liberty of passing in review the twenty years' life of a generalization which is known under the name of periodic law. It was in March, 1869, that I ventured to lay before the then youthful Russian Chemical Society the ideas upon the same subject which I had expressed in my just written "Principles of Chemistry."

Without entering into details, I will give the conclusions I then arrived at in the very words I used:—

1. The elements, if arranged according to their atomic weights, exhibit an evident *periodicity* of properties.

2. Elements which are similar as regards their chemical properties have atomic weights which are either of nearly the same value (*e. g.*, platinum, iridium, osmium) or which increase regularly (*e. g.*, potassium, rubidium, cæsium).

3. The arrangement of the elements, or of groups of elements, in the order of their atomic weights, corresponds to their so-called *valencies*, as well as, to some extent, to their distinctive chemical properties—as is apparent, among other series, in that of lithium, beryllium, barium, carbon, nitrogen, oxygen, and iron.

4. The elements which are the most widely diffused have small atomic weights.

5. The magnitude of the atomic weight determines the character of the element, just as the magnitude of the molecule determines the character of a compound.

6. We must expect the discovery of many yet unknown elements—for example, elements analogous to aluminum and silicon, whose atomic weight would be between 65 and 75.

7. The atomic weight of an element may sometimes be amended by a knowledge of those of the contiguous elements. Thus, the atomic weight of tellurium must lie between 123 and 126, and cannot be 128.

8. Certain characteristic properties of the elements can be foretold from their atomic weights.

The aim of this communication will be fully attained if I succeed in drawing the attention of investigators to those relations which exist between the atomic weights of dissimilar elements, which, so far as I know, have hitherto been almost completely neglected. I believe that the solution of some of the most important problems of our science lies in researches of this kind.

To-day, twenty years after the above conclusions were formulated, they may still be considered as expressing the essence of the now well known periodic law.

Reverting to the epoch terminating with the sixties, it is proper to indicate three series of data without the knowledge of which the periodic law could not have been discovered, and which rendered its appearance natural and intelligible.

In the first place, it was at that time that the numerical value of atomic weights became definitely known. Ten years earlier such knowledge did not exist, as may be gathered from the fact that in 1860 chemists from all parts of the world met at Karlsruhe in order to come to some agreements, if not with respect to views relating to atoms, at any rate as regards their definite representation. Many of those present probably remember how vain were the hopes of coming to an understanding, and how much ground was gained at that congress by the followers of the unitary theory so brilliantly represented by Cannizzaro. I vividly remember the impression produced by his speeches, which admitted of no compromise, and seemed to advocate truth itself, based on the conceptions of Avogadro, Gerhardt, and Regnault, which at that time were far from being generally recognized. And though no understanding could be arrived at, yet the objects of the meeting were attained, for the ideas of Cannizzaro proved, after a few years, to be the only ones which could stand criticism, and which represented an atom as—"the smallest portion of an element which enters into a mole-

cule of its compound." Only such real atomic weights—not conventional ones—could afford a basis for generalization. It is sufficient, by way of example, to indicate the following cases in which the relation is seen at once and is perfectly clear:

| | | |
|---|---|---|
| K = 39 | Rb = 85 | Cs = 133 |
| Ca = 40 | Sr = 87 | Ba = 137 |

whereas with the equivalents then in use—

| | | |
|---|---|---|
| K = 39 | Rb = 85 | Cs = 133 |
| Ca = 20 | Sr = 43.5 | Ba = 68.5 |

the consecutiveness of change in atomic weight, which with the true values is so evident, completely disappears.

Secondly, it had become evident during the period 1860-70, and even during the preceding decade, that the relations between the atomic weights of analogous elements were governed by some general and simple laws. Cooke, Cremers, Gladstone, Gmelin, Lenssen, Pettenkofer, and especially Dumas, had already established many facts bearing on that view. Thus Dumas compared the following groups of analogous elements with organic radicles—

| | Diff. | | Diff. | | Diff. | | Diff |
|---|---|---|---|---|---|---|---|
| Li = 7 | | Mg = 12 | | P = 31 | | O = 8 | |
| | —16 | | —8 | | —44 | | —8 |
| Na = 23 | | Ca = 20 | | As = 75 | | S = 16 | |
| | —16 | | —3×8 | | —44 | | —3×8 |
| K = 39 | | Sr = 44 | | Sb = 119 | | Se = 40 | |
| | | | —3×8 | | —2×44 | | —3×8 |
| | | Ba = 68 | | Bi = 207 | | Te = 64 | |

and pointed out some really striking relationships, such as the following

F = 19.
Cl = 35.5 = 19 + 16.5
Br = 80 = 19 + 2 × 16.5 + 28
I = 127 = 2 × 19 + 2 × 16.5 + 2 × .28.

A. Strecker, in his work, "*Theorien und Experimente zur Bestimmung der Atomgewichte der Elemente*" (Braunschweig, 1859), after summarizing the data relating to the subject, and pointing out the remarkable series of equivalents—

Cr = 26.2 Mn = 27.6 Fe = 28 Ni = 29 Co = 30 Cu = 31.7
Zn = 32.5

remarks that: It is hardly probable that all the above-mentioned relations between the atomic weights (or equivalents) of chemically analogous elements are merely accidental. We must, however, leave to the

future the discovery of the *law* of the relations which appears in these figures.

In such attempts at arrangement and in such views are to be recognized the real forerunners of the periodic law; the ground was prepared for it between 1860 and 1870, and that it was not expressed in a determinate form before the end of the decade may, I suppose, be ascribed to the fact that only analogous elements had been compared. The idea of seeking for a relation between the atomic weights of all the elements was foreign to the ideas then current, so that neither the *vis tellurique* of De Chancourtois, nor the law of octaves of Newlands like Dumas and Strecker, more than Lenssen and Pettenkofer, had made an approach to the periodic law and had discovered its germs. The solution of the problem advanced but slowly, because the facts, but not the law, stood foremost in all attempts; and the law could not awaken a general interest so long as elements, having no apparent connection with each other, were included in the same octave, as, for example:—

1st octave of Newlands, H, F, Cl, Co & Ni, Br, Pd, I, Pt & Ir.

7th ditto, O, S, Fe, Se, Rh & Ru, Te, Au, Os or Th.

Analogies of the above order seemed quite accidental, and the more so as the octave contained occasionally ten elements instead of eight, and when two such elements as Ba and V, Co and Ni, or Rh and Ru, occupied one place in the octave. Nevertheless the fruit was ripening, and I now see clearly that Strecker, De Chancourtois, and Newlands stood foremost in the way towards the discovery of the periodic law, and that they merely wanted the boldness necessary to place the whole question at such a height that its reflection on the facts could be clearly seen.

A third circumstance which revealed the periodicity of chemical elements was the accumulation, by the end of the sixties, of new information respecting the rare elements, disclosing their many-sided relations to the other elements and to each other. The researches of Marignac on niobium, and those of Roscoe on vanadium, were of special moment. The striking analogies between vanadium and phosphorus on the one hand, and between vanadium and chromium on the other, which are so apparent in the investigations connected with that element, naturally induced the comparison of V=51 with Cr=52, Nb=94 with Mo=96, Ta=192 with W=194; while, on the other hand, P=31 could be compared with S=32, As=75 with Se=79, and Sb=120 with Te=125. From such approximations there remained but one step to the discovery of the law of periodicity.

The law of periodicity was thus a direct outcome of the stock of generalizations and established facts which had accumulated by the end of the decade 1860-70: it is an embodiment of those data in a more or less systematic expression. Where, then, lies the secret of the special importance which has since been attached to the periodic law, and has raised it to the position of a generalization which has already given to chemistry unexpected aid, and which promises to be far more fruitful in the future and to impress upon several branches of chemical research a peculiar and original stamp? The remaining part of my communication will be an attempt to answer this question.

In the first place, we have the circumstance that, as soon as the law made its appearance, it demanded a revision of many facts which were considered by chemists as fully established by existing experience. I shall return later on, briefly to this subject, but I wish now to remind you that the periodic law, by insisting on the necessity for a revision of supposed facts, exposed itself at once to destruction in its very origin. Its first requirements, however, have been almost entirely satisfied during the last twenty years; the supposed facts have yielded to the law, thus proving that the law itself was a legitimate induction from the verified facts. But our inductions from data have often to do with such details of a science so rich in facts, that only generalizations which cover a wide range of important phenomena can attract general attention. What were the regions touched on by the periodic law? This is what we shall now consider.

The most important point to notice is, that periodic functions, used for the purpose of expressing changes which are dependent on variations of time and space, have been long known. They are familiar to the mind when we have to deal with motion in closed cycles, or with any kind of deviation from a stable position, such as occurs in pendulum oscillations. A like periodic function became evident in the case of the elements, depending on the mass of the atom. The primary conception of the masses of bodies, or of the masses of atoms, belongs to a category which the present state of science forbids us to discuss, because as yet we have no means of dissecting or analyzing the conception. All that was known of functions dependent on masses derived its origin from Galileo and Newton, and indicated that such functions either increase or decrease with the increase of mass, like the attraction of celestial bodies. The numerical expression of the phenomena was always found to be proportional to the mass, and in no case was an increase of mass

followed by a recurrence of properties such as is disclosed by the periodic law of the elements. This constituted such a novelty in the study of the phenomena of nature that, although it did not lift the veil which conceals the true conception of mass, it nevertheless indicated that the explanation of that conception must be searched for in the masses of the atoms; the more so, as all masses are nothing but aggregations, or additions of chemical atoms which would be best described as chemical individuals. Let me remark, by the way, that though the Latin word "*individual*" is merely a translation of the Greek word "*atom,*" nevertheless history and custom have drawn a sharp distinction between the two words, and the present chemical conception of atoms is nearer to that defined by the Latin word than by the Greek, although this latter also has acquired a special meaning which was unknown to the classics. The periodic law has shown that our chemical individuals display a harmonic periodicity of properties dependent on their masses. Now natural science has long been accustomed to deal with periodicities observed in nature, to seize them with the vise of mathematical analysis, to submit them to the rasp of experiment. And these instruments of scientific thought would surely long since have mastered the problem connected with the chemical elements, were it not for a new feature which was brought to light by the periodic law and which gave a peculiar and original character to the periodic function.

If we mark on an axis of abscissæ a series of lengths proportional to angles, and trace ordinates which are proportional to sines or other trigonometrical functions, we get periodic curves of a harmonic character. So it might seem, at first sight, that with the increase of atomic weights the function of the properties of the elements should also vary in the same harmonious way. But in this case there is no such continuous change as in the curves just referred to, because the periods do not contain the infinite number of points constituting a curve, but a *finite* number only of such points. An example will better illustrate this view. The atomic weights—

Ag=108 Cd=112 In=113 Sn=118 Sb=120
Te=125 I=127

steadily increase, and their increase is accompanied by a modification of many properties, which constitutes the essence of the periodic law. Thus, for example, the densities of the above elements decrease steadily, being respectively—

10.5 8.6 7.4 7.2 6.7 6.4 4.9

while their oxides contain an increasing quantity of oxygen—

$Ag_2O$ $Cd_2O_2$ $In_2O_3$ $Sn_2O_4$ $Sb_2O_5$ $Te_2O_6$ $I_2O_7$

But to connect by a curve the summits of the ordinates expressing any of these properties would involve the rejection of Dalton's law of multiple proportions. Not only are there no intermediate elements between silver, which gives AgCl, and cadmium, which gives $CdCl_2$, but according to the very essence of the periodic law, there can be none: in fact a uniform curve would be inapplicable in such a case, as it would lead us to expect elements possessed of special properties at any point of the curve. The periods of the elements have thus a character very different from those which are so simply represented by geometers. They correspond to points, to numbers, to sudden changes destitute of intermediate steps or positions, in the absence of elements intermediate between, say silver and cadmium, or aluminum and silicon, we must recognize a problem to which no direct application of the analysis of the infinitely small can be made. Therefore, neither the trigonometrical functions proposed by Ridberg and Flavitzky, nor the pendulum oscillations suggested by Crookes, nor the cubical curves of the Rev. Mr. Haughton, which have been proposed for expressing the periodic law, from the nature of the case, can represent the periods of the chemical elements. If geometrical analysis is to be applied to this subject, it will require to be modified in a special manner. It must find the means of representing in a special way, not only such long periods, as that comprising—

K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br,

but short periods like the following:—

Na Mg Al Si P S Cl.

In the theory of numbers only do we find problems analogous to ours, and two attempts at expressing the atomic weights of the elements by algebraic formulæ seem to be deserving of attention, although none of them can be considered as a complete theory, nor as promising finally to solve the problem of the periodic law. The attempt of E. J. Mills (1886) does not even aspire to attain this end. He considers that all atomic weights can be expressed by a logarithmic function,

$$15\,(n - 0.9375^t),$$

in which the variables $n$ and $t$ are whole numbers. Thus, for oxygen, $n=2$, and $t=1$, whence its atomic weight is $=15.94$; in the case of chlorine, bromine, and iodine, $n$ has respective values of 3, 6, and 9,

whilst $t=7$, 6, and 9; in the case of potassium, rubidium, and cæsium, $n=4$, 6, and 9, and $t=14$, 18, and 20.

Another attempt was made in 1888 by B. N. Tchitchérin. Its author places the problem of the periodic law in the first rank, but as yet he has investigated the alkali metals only. Tchitchérin first noticed the simple relations existing between the atomic volumes of all alkali metals; they can be expressed, according to his views, by the formula

$$A(2-0.00535An),$$

where A is the atomic weight, and $n$ is equal to 8 for lithium and sodium, to 4 for potassium, to 3 for rubidium, and to 2 for cæsium. If $n$ remained equal to 8 during the increase of A, the volume would become zero at $A=46\ 2\text{-}3$, and it would reach its maximum at $A=23\ 1\text{-}3$. The close approximation of the number 46 2-3 to the differences between the atomic weights of analogous elements (such as Cs-Rb, I-Br, and so on); the close correspondence of the number 23 1-3 to the atomic weight of sodium; the fact of $n$ being necessarily a whole number, and several other aspects of the question, induce Tchitchérin to believe that they afford a clue to the understanding of the nature of the elements; we must, however, await the full development of his theory before pronouncing judgment on it. What we can at present only be certain of is this: that attempts like the two above named must be repeated and multiplied, because the periodic law has clearly shown that the masses of the atoms increase abruptly, by steps, which are clearly connected in some way to Dalton's law of multiple proportions; and because the periodicity of the elements finds expression in the transition from RX to $RX_2$, $RX_3$, $RX_4$, and so on till $RX_8$, at which point, the energy of the combining forces being exhausted, the series begins anew from RX to $RX_2$, and so on.

While connecting by new bonds the theory of the chemical elements with Dalton's theory of multiple proportions, or atomic structure of bodies, the periodic law opened for natural philosophy a new and wide field for speculation. Kant said that there are in the world "two things which never cease to call for the admiration and reverence of man: the moral law within ourselves, and the stellar sky above us. But when we turn our thoughts towards the nature of the elements and the periodic law, we must add a third subject, namely, "the nature of the elementary individuals which we discover everywhere around us." Without them the stellar sky itself is inconceivable; and in the atoms we see at once their peculiar individualities, the infinite multiplicity of the

individuals, and the submission of their seeming freedom to the general harmony of nature.

Having thus indicated a new mystery of nature, which does not yet yield to rational conception, the periodic law, together with the revelations of spectrum analysis, have contributed to again revive an old but remarkably long-lived hope—that of discovering, if not by experiment, at least by a mental effort, the *primary matter*—which had its genesis in the minds of the Grecian philosophers, and has been transmitted, together with many other ideas of the classic period, to the heirs of their civilization. Having grown, during the times of the alchemists up to the period when experimental proof was required, the idea has rendered good service; it induced those careful observations and experiments which later on called into being the works of Scheele, Lavoisier, Priestley, and Cavendish. It then slumbered awhile, but was soon awakened by the attempts either to confirm or to refute the ideas of Prout as to the multiple proportion relationship of the atomic weights of all the elements. And once again the inductive or experimental method of studying Nature gained a direct advantage from the old Pythagorean idea: because atomic weights were determined with an accuracy formerly unknown. But again the idea could not stand the ordeal of experimental test, yet the prejudice remains and has not been uprooted, even by Stas; nay, it has gained new vigor, for we see that all which is imperfectly worked out, new and unexplained, from the still scarcely studied rare metals to the hardly perceptible nebulæ, have been used to justify it. As soon as spectrum analysis appears as a new and powerful weapon of chemistry, the idea of a primary matter is immediately attached to it. From all sides we see attempts to constitute the imaginary substance helium, the so much longed for primary matter. No attention is paid to the circumstance that the helium line is only seen in the spectrum of the solar protuberances, so that its universality in Nature remains as problematic as the primary matter itself; nor to the fact that the helium line is wanting amongst the Fraunhofer lines of the solar spectrum, and thus does not answer to the brilliant fundamental conception which gives its real force to spectrum analysis.

And finally, no notice is even taken of the indubitable fact that the brilliancies of the spectral lines of the simple substances vary under different temperatures and pressures; so that all probabilities are in favor of the helium line simply belonging to some long since known element placed under such conditions of temperature, pressure, and gravity as

have not yet been realized in our experiments. Again, the idea that the excellent investigations of Lockyer of the spectrum of iron can be interpreted in favor of the compound nature of that element, evidently must have arisen from some misunderstanding. The spectrum of a compound certainly does not appear as a sum of the spectra of its components; and therefore the observations of Lockyer can be considered precisely as a proof that iron undergoes no other changes at the temperature of the sun than those which it experiences in the voltaic arc—provided the spectrum of iron is preserved. As to the shifting of some of the lines of the spectrum of iron while the other lines maintain their positions, it can be explained, as shown by M. Kleiber (Journal of the Russian Chemical and Physical Society, 1885, 147) by the relative motion of the various strata of the sun's atmosphere, and by Zöllner's laws of the relative brilliancies of different lines of the spectrum. Moreover, it ought not to be forgotten that if iron were really proved to consist of two or more unknown elements, we should have an increase in the number of our elements—not a reduction, and still less a reduction of all of them to one single primary matter.

Feeling that spectrum analysis will not yield a support to the Pythagorean conception, its modern promoters are so bent upon its being confirmed by the periodic law, that the illustrious Berthellot, in his work, "*Les Origines de l'Alchimie,*" 1885, 313, has simply mixed up the fundamental idea of the law of periodicity with the ideas of Prout, the alchemists, and Democritus about primary matter. But the periodic law, based as it is on the solid and wholesome ground of experimental research, has been evolved independently of any conception as to the nature of the elements; it does not in the least originate in the idea of a unique matter, and it has no historical connection with that relic of the torments of classical thought, and therefore it affords no more indication of the unity of matter or of the compound character of our elements, than the law of Avogadro, or the law of specific heats, or even the conclusions of spectrum analysis. None of the advocates of a unique matter have ever tried to explain the law from the standpoint of ideas taken from a remote antiquity when it was found convenient to admit the existence of many gods—and of a unique matter.

When we try to explain the origin of the idea of a unique primary matter, we easily trace that in the absence of inductions from experiment it derives its origin from the scientifically philosophical attempt at discovering some kind of unity in the immense diversity of individualities

which we see around. In classical times such a tendency could only be satisfied by conceptions about the immaterial world. As to the material world, our ancestors were compelled to resort to some hypothesis, and they adopted the idea of unity in the formative material, because they were not able to evolve the conception of any other possible unity in order to connect the multifarious relations of matter. Responding to the same legitimate scientific tendency, natural science has discovered throughout the universe a unity of plan, a unity of forces, and the convincing conclusions of modern science compel everyone to admit these kinds of unity. But while we admit unity in many things, we none the less must also explain the individuality and the apparent diversity which we cannot fail to trace everywhere. It has been said of old, "Give us a fulcrum, and it will become easy to displace the earth." So also we must say, "Give us something that is individualised, and the apparent diversity will be easily understood." Otherwise, how could unity result in a multitude?

After a long and painstaking research, natural science has discovered the individualities of the chemical elements, and therefore it is now capable not only of analysing, but also of synthesising: it can understand and grasp generality and unity, as well as the individualised and the multifarious. The general and universal, like time and space, like force and motion, vary uniformly; the uniform admit of interpolations, revealing every intermediate phase. But the multitudinous, the individualized—such as ourselves, or the chemical elements, or the members of a peculiar periodic function of the elements, or Dalton's multiple proportions—is characterized in another way: we see in it, side by side with a connecting general principle, leaps, breaks of continuity, points which escape from the analysis of the infinitely small—an absence of complete intermediate links. Chemistry has found an answer to the question as to the causes of multitudes; and while retaining the conception of many elements, all submitted to the discipline of a general law, it offers an escape from the Indian Nirvana—the absorption in the universal, replacing it by the individualised. However, the place for individuality is so limited by the all-grasping, all-powerful universal, that it is merely a point of support for the understanding of multitude in unity.

Having touched upon the metaphysical bases of the conception of a unique matter which is supposed to enter into the composition of all bodies, I think it necessary to dwell upon another theory, akin to the

above conception-theory of the compound character of the elements now admitted by some—and especially upon one particular circumstance which, being related to the periodic law, is considered to be an argument in favour of that hypothesis.

Dr. Pelopidas, in 1883, made a communication to the Russian Chemical and Physical Society on the periodicity of the hydrocarbon radicles, pointing out the remarkable parallelism which was to be noticed in the change of properties of hydrocarbon radicles and elements when classed in groups. Professor Carnelley, in 1886, developed a similar parallelism. The idea of M. Pelopidas will be easily understood if we consider the series of hydrocarbon radicles which contain, say, 6 atoms of carbon:—

| I. | II. | III. | IV. | V. | VI. | VII. | VIII. |
|---|---|---|---|---|---|---|---|
| $C_6H_{13}$ | $C_6H_{12}$ | $C_6H_{11}$ | $C_6H_{10}$ | $C_6H_9$ | $C_6H_8$ | $C_6H_7$ | $C_6H_6$ |

The first of these radicles, like the elements of the first group, combines with Cl, OH, and so on, and gives the derivatives of hexyl alcohol, $C_6H_{13}$ (OH); but, in proportion as the number of hydrogen atoms decreases, the capacity of the radicles, of combining with, say, the halogens, increases. $C_6H_{12}$ already combines with 2 atoms of chlorine; $C_6H_{11}$ with 3 atoms, and so on. The last members of the series comprise the radicles of acids: thus $C_6H_8$, which belongs to the sixth group, gives, like sulphur, a bibasic acid, $C_6H_8O_2$ $(OH)_2$, which is homologous with oxalic acid. The parallelism can be traced still further, because $C_6H_5$ appears as a monovalent radicle of benzine, and with it begins a new series of aromatic derivatives, so analogous to the derivatives of the fat series. Let me also mention another example from among those which have been given by M. Pelopidas. Starting from the alkaline radicle of monomethylammonium, $N(CH_3)H_3$, or $NCH_6$, which presents many analogies with the alkaline metals of the first group, he arrives, by successively diminishing the number of atoms of hydrogen, at a 7th group which contains cyanogen, Cn, which has long since been compared to the halogens of the seventh group.

The most important consequence which, in my opinion, can be drawn from the above comparison is that the periodic law, so apparent in the elements, has a wider application than might appear at first sight; it opens up a new vista of chemical evolutions. But, while admitting the fullest parallelism between the periodicity of the elements and that of the compound radicles, we must not forget that in the periods of the hydrocarbon radicles we have a *decrease* of mass as we pass from the

representatives of the first group to the next, while in the periods of the elements the mass *increases* during the progression. It thus becomes evident that we cannot speak of an identity of periodicity in both cases, unless we put aside the ideas of mass and attraction, which are the real corner-stones of the whole of natural science, and even enter into those very conceptions of simple substances which came to light a full hundred years later than the immortal principles of Newton.

From the foregoing, as well as from the failures of so many attempts at finding in experiment and speculation a proof of the compound character of the elements and of the existence of primordial matter, it is evident, in my opinion, that this theory must be classed among mere utopias. But utopias can only be combated by freedom of opinion, by experiment, and by new utopias. In the republic of scientific theories freedom of opinions is guaranteed. It is precisely that freedom which permits me to criticise openly the widely-diffused idea as to the unity of matter in the elements. Experiments and attempts at confirming that idea have been so numerous that it really would be instructive to have them all collected together, if only to serve as a warning against the repetition of old failures. And now as to new utopias which may be helpful in the struggle against the old ones, I do not think it quite useless to mention a phantasy of one of my students who imagined that the weight of bodies does not depend upon their mass, but upon the character of the motion of their atoms. The atoms, according to this new utopian, may all be homogeneous or heterogeneous, we know not which; we know them in motion only, and that motion they maintain with the persistence as the stellar bodies maintain theirs. The weights of atoms differ only in consequence of their various modes and quantity of motion; the heaviest atoms may be much simpler than an atom of hydrogen—the manner in which it moves causes it to be heavier. My interlocutor even suggested that the view which attributes the greater complexity to the lighter elements finds confirmation in the fact that the hydrocarbon radicles mentioned by Pelopidas, while becoming lighter as they lose hydrogen, change their properties periodically in the same manner as the elements change theirs, according as the atoms grow heavier.

The French proverb, *La critique est facile, mais l'art est difficile,* however, may well be reversed in the case of all such ideal views, as it is much easier to formulate than to criticise them. Arising from the virgin soil of newly-established facts, the knowledge relating to the

elements, to their masses, and to the periodic changes of their properties has given a motive for the formation of utopian hypotheses, probably because they could not be foreseen by the aid of any of the various metaphysical systems, and exist, like the idea of gravitation, as an independent outcome of natural science, requiring the acknowledgment of general laws, when these have been established with the same degree of persistency as is indispensable for the acceptance of a thoroughly established fact. Two centuries have elapsed since the theory of gravitation was enunciated, and although we do not understand its cause, we still must regard gravitation as a fundamental conception of natural philosophy, a conception which has enabled us to perceive much more than the metaphysicians did or could with their seeming omniscience. A hundred years later the conception of the elements arose; it made chemistry what it now is; and yet we have advanced as little in our comprehension of simple substances since the times of Lavoisier and Dalton as we have in our understanding of gravitation. The periodic law of the elements is only twenty years old; it is not surprising, therefore, that, knowing nothing about the causes of gravitation and mass, or about the nature of the elements, we do not comprehend the *rationale* of the periodic law. It is only by collecting established laws—that is, by working at the acquirement of truth—that we can hope gradually to lift the veil which conceals from us the causes of the mysteries of Nature and to discover their mutual dependency. Like the telescope and the microscope, laws founded on the basis of experiments are the instruments and means of enlarging our mental horizon.

In the remaining part of my communication I shall endeavour to show, and as briefly as possible, in how far the periodic law contributes to enlarge our range of vision. Before the promulgation of this law the chemical elements were mere fragmentary, incidental facts in Nature; there was no special reason to expect the discovery of new elements, and the new ones which were discovered from time to time appeared to be possessed of quite novel properties. The law of periodicity first enabled us to perceive undiscovered elements at a distance which formerly was inaccessible to chemical vision; and long ere they were discovered new elements appeared before our eyes possessed of a number of well-defined properties. We now know three cases of elements whose existence and properties were foreseen by the instrumentality of the periodic law. I need but mention the brilliant discovery of *gallium*, which proved to correspond to eka-aluminum of the periodic

law, by Lecoq de Boisbaudran, of *scandium,* corresponding to *ekaboron,* by Nilson; and of *germanium,* which proved to correspond in all respects to *ekasilicon,* by Winkler. When, in 1871, I described to the Russian Chemical Society the properties, clearly defined by the periodic law, which such elements ought to possess, I never hoped that I should be able to mention their discovery to the Chemical Society of Great Britain as a confirmation of the exactitude and the generality of the periodic law. Now that I have had the happiness of doing so, I unhesitatingly say that, although greatly enlarging our vision, even now the periodic law needs further improvements in order that it may become a trustworthy instrument in further discoveries.

## SIR NORMAN LOCKYER

Sir Joseph Norman Lockyer was born at Rugby, England, May 17, 1836. He entered the War Office in 1857. His great scientific education is largely self-acquired. He is one of the originators of the meteoric hypothesis that the earth and other spheres are the result of the aggregation of meteorites. In chemistry he is working out the train of thought suggested by the periodic law that the atoms which we know are themselves compounds.

### THE CHEMISTRY OF THE STARS

When, on returning from India, I found that you had during my absence done me the honor of unanimously electing me your president, I began to cast about for a subject on which to address you. Curiously enough, shortly afterwards an official inquiry compelled me to make myself acquainted with the early doings of the Royal Commission of the Exhibition of 1851, on which I have lately been elected to serve, and in my reading I found a full account of the establishment of your institute; of the laying of the foundation stone by the late Prince Consort in 1855, and of his memorable speech on that occasion. Here, I thought, was my subject; and when I heard that the admirable work

done by this and other local institutions had determined the inhabitants of this important city and neighborhood to crown the edifice by the foundation of a university, I thought the matter settled.

This idea, however, was nipped in the bud by a letter which informed me that the hope had been expressed that I should refer to some branch of astronomical work. I yielded at once, and because I felt that I might thus be able to show cause why the making of knowledge should occupy a large place in your new university, and thus distinguish it from other universities more or less decadent.

The importance of practical work, the educational value of the seeking after truth by experiment and observation on the part of even young students, are now generally recognized. That battle has been fought and won. But there is a tendency in the official direction of seats of learning to consider what is known to be useful, because it is used, in the first place. The fact that the unknown, that is, the unstudied, is the mine from which all scientific knowledge with its million applications has been won is too often forgotten.

Bacon, who was the first to point out the importance of experiment in the physical sciences, and who predicted the applications to which I have referred, warns us that "*lucifera experimenta non fructifera quaerenda;*" and surely we should highly prize those results which enlarge the domain of human thought and help us to understand the mechanism of the wonderful universe in which our lot is cast, as well as those which add to the comfort and the convenience of our lives.

It would be also easy to show by many instances how researches, considered ideally useless at the time they were made, have been the origin of the most tremendous applications. One instance suffices. Faraday's trifling with wires and magnets has already landed us in one of the greatest revolutions which civilization has witnessed; and where the triumphs of electrical science will stop no man can say.

This is a case in which the useless has been rapidly sublimed into utility so far as our material wants are concerned.

I propose to bring to your notice another "useless" observation suggesting a line of inquiry which I believe sooner or later is destined profoundly to influence human thought along many lines.

Fraunhofer at the beginning of this century examined sunlight and starlight through a prism. He found that the light received from the sun differed from that of the stars. So uselss did his work appear that we had to wait for half a century till any considerable advance was

made. It was found at last that the strange "lines" seen and named by Fraunhofer were precious indications of the chemical substances present in worlds immeasurably remote. We had, after half a century's neglect, the foundation of solar and stellar chemistry, an advance in knowledge equaling any other in its importance.

In dealing with my subject I shall first refer to the work which has been done in more recent years with regard to this chemical conditioning of the atmospheres of stars, and afterwards very briefly show how this work carries us into still other new and wider fields of thought.

The first important matter which lies on the surface of such a general inquiry as this is that if we deal with the chemical elements as judged by the lines in their spectra we know for certain of the existence of oxygen, of nitrogen, of argon, representing one class of gases, in no celestial body whatever; whereas, representing other gases, we have a tremendous demonstration of the existence of all the known lines of hydrogen and helium.

We see, then, that the celestial sorting out of gases is quite different from the terrestrial one.

Taking the substances classed by the chemist as non-metals, we find carbon and silicium—I prefer, on account of its stellar behavior, to call it silicium, though it is old fashioned—present in celestial phenomena. We have evidence of this in the fact that we have a considerable development of carbon in some stars and an indication of silicium in others. But these are the only non-metals observed. Now, with regard to the metallic substances which we find, we deal chiefly with calcium, strontium, iron, and magnesium. Others are not absolutely absent, but their percentage quantity is so small that they are negligible in a general statement.

Now do these chemical elements exist indiscriminately in all the celestial bodies, so that practically, from a chemical point of view, the bodies appear to us of similar chemical constitution? No; it is not so.

From the spectra of those stars which resemble the sun, in that they consist of an interior nucleus surrounded by an atmosphere which absorbs the light of the nucleus, and which, therefore, we study by means of this absorption, it is to be gathered that the atmospheres of some stars are chiefly gaseous—i. e., consisting of elements we recognize as gases here—of others chiefly metallic, of others again mainly composed of carbon or compounds of carbon.

Here, then, we have spectroscopically revealed the fact that there is

considerable variation in the chemical constituents which build up the stellar atmospheres.

This, though a general, is still an isolated statement. Can we connect it with another? One of the laws formulated by Kirchhoff in the infancy of spectroscopic inquiry has to do with the kind of radiation given out by bodies at different temperatures. A poker placed in a fire first becomes red, and, as it gets hotter, white hot. Examined in a spectroscope, we find that the red condition comes from the absence of blue light; that the white condition comes from the gradual addition of blue as the temperature increases.

The law affirms that the hotter a mass of matter is the farther its spectrum extends into the ultraviolet.

Hence the hotter a star is the farther does its complete or continuous spectrum lengthen out toward the ultraviolet and the less it is absorbed by cooler vapors in its atmosphere.

Now, to deal with three of the main groups of stars, we find the following very general result:

| | |
|---|---|
| Gaseous stars | Longest spectrum. |
| Metallic stars | Medium spectrum. |
| Carbon stars | Shortest spectrum |

We have now associated two different series of phenomena, and we are enabled to make the following statement:

| | |
|---|---|
| Gaseous stars | Highest temperature. |
| Metallic stars | Medium temperature. |
| Carbon stars | Lowest temperature. |

Hence the differences in apparent chemical constitutions are associated with differences of temperature.

Can we associate with the two to which I have already called attention still a third class of facts? Laboratory work enables us to do this. When I began my inquiries the idea was, one gas or vapor, one spectrum. We now know that this is not true; the systems of bright lines given out by radiating substances change with the temperature.

We can get the spectrum of a well known compound substance—say carbonic oxide; it is one special to the compound; we increase the temperature so as to break up the compound, and we then get the spectra of its constituents, carbon and oxygen.

But the important thing in the present connection is that the spectra of the chemical elements behave exactly in the same way as the spectra of known compounds do when we employ temperatures far higher than those which break up the compounds; and indeed in some

cases the changes are more marked. For brevity I will take for purposes of illustration three substances, and deal with one increase of temperature only, a considerable one and obtainable by rendering a substance incandescent, first by a direct current of electricity, as happens in the so-called "arc lamps" employed in electric lighting, and next by the employment of a powerful induction coil and battery of Leyden jars. In laboratory parlance we pass thus from the arc to the jar-spark. In the case of magnesium, iron, and calcium, the changes observed on passing from the temperature of the arc to that of the spark have been minutely observed. In each, new lines are added or old ones are intensified at the higher temperature. Such lines have been termed "enhanced lines."

These enhanced lines are not seen alone; outside the region of high temperature in which they are produced, the cooling vapors give us the cool lines. Still we can conceive the enhanced lines to be seen alone at the highest temperature in a space sufficiently shielded from the action of all lower temperatures, but such a shielding is beyond our laboratory expedients.

In watching the appearance of these special enhanced lines in stellar spectra we have a third series of phenomena available, and we find that the results are absolutely in harmony with what has gone before. Thus:

| | | |
|---|---|---|
| **Gaseous stars** | **Highest temperature** | **Strong helium and faint enhanced lines.** |
| **Metallic stars** | **Medium temperature** | **Feeble helium and strong enhanced lines.**<br>**No helium and strong arc lines.** |
| **Carbon stars** | **Lowest temperature** | **Faint arc lines.** |

It is clear now, not only that the spectral changes in stars are associated with, or produced by, changes of temperature, but that the study of the enhanced spark and the arc lines lands us in the possibility of a rigorous stellar thermometry, such lines being more easy to observe than the relative lengths of spectrum.

Accepting this, we can take a long stride forward and, by carefully studying the chemical revelations of the spectrum, classify the stars along a line of temperature. But which line? Were all the stars in popular phraseology created hot? If so, we should simply deal with the running down of temperature, and because all the hottest stars are chemically alike, all cooler stars would be alike. But there are two very distinct groups of coolest stars; and since there are two different kinds of coolest stars, and only one kind of hottest stars, it cannot be merely a question either of a running up or a running down of temperature.

Many years of very detailed inquiry have convinced me that all stars save the hottest must be sorted out into two series—those getting hotter and those, like our sun, getting cooler, and that the hottest stage in the history of a star is reached near the middle of its life.

The method of inquiry adopted has been to compare large-scale photographs of the spectra of the different stars taken by my assistants at South Kensington; the complete harmony of the results obtained along various lines of other work carries conviction with it.

We find ourselves here in the presence of minute details exhibiting the workings of a chemical law, associated distinctly with temperature; and more than this, we are also in the presence of high temperature furnaces, entirely shielded by their vastness from the presence of those distracting phenomena which we are never free from in the most perfect conditions of experiment we can get here.

What, then, is the chemical law? It is this: In the very hottest stars we deal with the gases hydrogen, helium, and doubtless others still unknown, almost exclusively. At the next lowest temperatures we find these gases being replaced by metals in the state in which they are observed in our laboratories when the most powerful jar-spark is employed. At a lower temperature still the gases almost disappear entirely, and the metals exist in the state produced by the electric arc. Certain typical stars showing these chemical changes may be arranged as follows:

| Stars getting hotter. | Hottest stars. | Stars cooling. |
|---|---|---|
| | Bellatrix | |
| ζ Tauri | | β Persei |
| Rigel | | γ Lyra |
| α Cygni | | Castor |
| γ Cygni | | Procyon |
| α Orionis | | Arcturus and Sun. |

This, then, is the result of our first inquiry into the existence of the various chemical elements in the atmospheres of stars generally. We get a great diversity, and we know that this diversity accompanies changes of temperature. We have also found that the sun, which we independently know to be a cooling star, and Arcturus are identical chemically.

We have now dealt with the presence of the various chemical elements generally in the atmospheres of stars. The next point we have to consider is, whether the absorption which the spectrum indicates for us takes place from top to bottom of the atmosphere or only in certain levels.

In many of these stars the atmosphere may be millions of miles high. In each the chemical substances in the hottest and coldest portions may be vastly different. The region, therefore, in which this absorption takes place, which spectroscopically enables us to discriminate star from star, must be accurately known before we can obtain the greatest amount of information from our inquiries.

Our next duty then, clearly, is to study the sun—a star so near us that we can examine the different parts of its atmosphere, which we cannot do in the case of the more distant stars. By doing this we may secure facts which will enable us to ascertain in what parts of the atmosphere the absorption takes place which produces the various phenomena on which the chemical classification has been based.

It is obvious that the general spectrum of the sun, like that of stars generally, is built up of all the absorptions which can make themselves felt in every layer of its atmosphere from bottom to top; that is, from the photosphere to the outermost part of the corona. Let me remind you that this spectrum is changeless from year to year.

Now, sun-spots are disturbances produced in the photosphere; and the chromosphere, with its disturbances, called prominences, lies directly above it. Here, then, we are dealing with the lowest part of the sun's atmosphere. We find first of all that, in opposition to the changeless general spectrum, great changes occur with the sun-spot period, both in the spots and chromosphere.

The spot spectrum is indicated, as was found in 1866, by the widening of certain lines; the chromospheric spectrum, as was found in 1868, by the appearance at the sun's limb of certain bright lines. In both cases the lines affected, seen at any one time, are relatively few in number.

In the spot spectrum, at a sun-spot minimum, we find iron lines chiefly affected; at a maximum they are chiefly of unknown or unfamiliar origin. At the present moment the affected lines are those recorded in the spectra of vanadium and scandium, with others never seen in a laboratory. That we are here far away from terrestrial chemical conditions is evidenced by the fact that there is not a gram of scandium available for laboratory use in the world at the present time.

Then we have the spectrum of the prominences and the chromosphere. That spectrum we are enabled to observe every day when the sun shines as conveniently as we can observe that of sun spots. The chromosphere is full of marvels. At first, when our knowledge of spectra was very much more restricted than now, almost all the lines

observed were unknown. In 1868 I saw a line in the yellow, which I found behaved very much like hydrogen, though I could prove that it was not due to hydrogen; for laboratory use the substance which gave rise to it I called helium. Next year I saw a line in the green at 1474 of Kirchhoff's scale. That was an unknown line, but in some subsequent researches I traced it to iron. From that day to this we have observed a large number of lines. They have gradually been dragged out from the region of the unknown, and many are now recognized as enhanced lines, to which I have already called attention as appearing in the spectra of metals at a very high temperature.

But useful as the method of observing the chromosphere without an eclipse, which enables us

"... to feel from world to world,"

as Tennyson has put it, has proved, we want an eclipse to see it face to face.

A tremendous flood of light has been thrown upon it by the use of large instruments constructed on a plan devised by Respighi and myself in 1871. These give us an image of the chromosphere painted in each one of its radiations, so that the exact locus of each chemical layer is revealed. One of the instruments employed during the Indian eclipse of this year is that used in photographing the spectra of stars, so that it is now easy to place photographs of the spectra of the chromosphere obtained during a total eclipse and of the various stars side by side.

I have already pointed out that the chemical classification indicated that the stars next above the sun in temperature are represented by $\gamma$ Cygni and Procyon, one on the ascending, the other on the descending branch of the temperature curve.

Studying the spectra photographed during the eclipse of this year we see that practically the lower part of the sun's atmosphere, if present by itself, would give us the lines which specialize the spectra of $\gamma$ Cygni or Procyon.

I recognize in this result a veritable Rosetta stone, which will enable us to read the celestial hieroglyphics presented to us in stellar spectra, and help us to study the spectra and to get at results much more distinctly and certainly than ever before.

One of the most important conclusions we draw from the Indian eclipse is that, for some reason or other, the lowest, hottest part of the sun's atmosphere does not write its record among the lines which build up the general spectrum so effectively as does a higher one.

There was another point especially important on which we hoped for information, and that was this: Up to the employment of the prismatic camera insufficient attention had been directed to the fact that in observations made by an ordinary spectroscope no true measure of the height to which the vapors or gases extended above the sun could be obtained; early observations, in fact, showed the existence of glare between the observer and the dark moon; hence it must exist between us and the sun's surroundings.

The prismatic camera gets rid of the effects of this glare, and its results indicate that the effective absorbing layer—that, namely, which gives rise to the Fraunhofer lines—is much more restricted in thickness than was to be gathered from the early observations.

We are justified in extending these general conclusions to all the stars that shine in the heavens.

So much, then, in brief, for solar teachings in relation to the record of the absorption of the lower parts of stellar atmospheres.

Let us next turn to the higher portions of the solar surroundings, to see if we can get any effective help from them.

In this matter we are dependent absolutely upon eclipses, and I shall fulfill my task very badly if I do not show you that the phenomena then observable when the so-called corona is visible, full of awe and grandeur to all, are also full of precious teaching to the student of science. This also varies like the spots and prominences with the sun-spot period.

It happened that I was the only person that saw both the eclipse of 1871 at the maximum of the sun-spot period and that of 1878 at minimum; the corona of 1871 was as distinct from the corona of 1878 as anything could be. In 1871 we got nothing but bright lines, indicating the presence of gases; namely, hydrogen and another, since provisionally called coronium. In 1878 we got no bright lines at all, so I stated that probably the changes in the chemistry and appearance of the corona would be found to be dependent upon the sun-spot period, and recent work has borne out that suggestion.

I have now specially to refer to the corona as observed and photographed this year in India by means of the prismatic camera, remarking that an important point in the use of the prismatic camera is that it enables us to separate the spectrum of the corona from that of the prominences.

One of the chief results obtained is the determination of the position

of several lines of probably more than one new gas, which, so far, have not been recognized as existing on the earth.

Like the lowest hottest layer, for some reason or other, this upper layer does not write its record among the lines which build up the general spectrum.

### GENERAL RESULTS REGARDING THE LOCUS OF ABSORPTION IN STELLAR ATMOSPHERES

We learn from the sun, then, that the absorption which defines the spectrum of a star is the absorption of a middle region, one shielded both from the highest temperature of the lowest reaches of the atmosphere, where most tremendous changes are continually going on and the external region where the temperature must be low, and where the metallic vapors must condense.

If this is true for the sun it must be equally true for Arcturus, which exactly resembles it. I go further than this, and say that in the presence of such definite results as those I have brought before you it is not philosophical to assume that the absorption may take place at the bottom of the atmosphere of one star or at the top of the atmosphere of another. The *onus probandi* rests upon those who hold such views.

So far I have only dealt in detail with the hotter stars, but I have pointed out that we have two distinct kinds of coolest ones, the evidence of their much lower temperature being the shortness of their spectra. In one of these groups we deal with absorption alone, as in those already considered; we find an important break in the phenomena observed; helium, hydrogen, and metals have practically disappeared, and we deal with carbon absorption alone.

But the other group of coolest stars presents us with quite new phenomena. We no longer deal with absorption alone, but accompanying it we have radiation, so that the spectra contain both dark lines and bright ones. Now, since such spectra are visible in the case of new stars, the ephemera of the skies, which may be said to exist only for an instant relatively, and when the disturbance which gives rise to their sudden appearance has ceased, we find their places occupied by nebulæ, we cannot be dealing here with stars like the sun, which has already taken some millions of years to slowly cool, and requires more millions to complete the process into invisibility.

The bright lines seen in the large number of permanent stars which resemble these fleeting ones—new stars, as they are called—are those discerned in the once mysterious nebulæ which, so far from being stars,

were supposed not many years ago to represent a special order of created things.

Now the nebulæ differ from stars generally in the fact that in their spectra we have practically to deal with radiation alone; we study them by their bright lines; the conditions which produce the absorption by which we study the chemistry of the hottest stars are absent.

### A NEW VIEW OF STARS

Here, then, we are driven to the perfectly new idea that some of the cooler bodies in the heavens, the temperature of which is increasing and which appear to us as stars, are really disturbed nebulæ.

What, then, is the chemistry of the nebulæ? It is mainly gaseous; the lines of helium and hydrogen and the flutings of carbon, already studied by their absorption in the groups of stars to which I have already referred, are present as bright ones.

The presence of the lines of the metals iron, calcium, and probably magnesium, shows us that we are not dealing with gases merely.

Of the enhanced metallic lines there are none; only the low temperature lines are present, so far as we yet know. The temperature, then, is low, and lowest of all in those nebulæ where carbon flutings are seen almost alone.

### A NEW VIEW OF NEBULAE

Passing over the old views, among them one that the nebulæ were holes in something dark which enabled us to see something bright beyond, and another that they were composed of a fiery fluid, I may say that not long ago they were supposed to be masses of gases only, existing at a very high temperature.

Now, since gases may glow at a low temperature as well as at a high one, the temperature evidence must depend upon the presence of cool metallic lines and the absence of the enhanced ones.

The nebulæ, then, are relatively cool collections of some of the permanent gases and of some cool metallic vapors, and both gases and metals are precisely those I have referred to as writing their records most visibly in stellar atmospheres.

Now, can we get more information concerning this association of certain gases and metals? In laboratory work it is abundantly recognized that all meteorites (and many minerals) when slightly heated give out permanent gases, and under certain conditions the spectrum

of the nebulæ may in this way be closely approximated to. I have not time to labor this point, but I may say that a discussion of all the available observations to my mind demonstrates the truth of the suggestion, made many years ago by Professor Tait before any spectroscopic facts were available, that the nebulæ are masses of meteorites rendered hot by collisions.

Surely human knowledge is all the richer for this indication of the connection between the nebulæ, hitherto the most mysterious bodies in the skies, and the "stones that fall from heaven."

### CELESTIAL EVOLUTION

But this is, after all, only a stepping stone, important though it be. It leads us to a vast generalization. If the nebulæ are thus composed, they are bound to condense to centers, however vast their initial proportions, however irregular the first distribution of the cosmic clouds which compose them. Each pair of meteorites in collision puts us in mental possession of what the final stage must be. We begin with a feeble absorption of metallic vapors round each meteorite in collision; the space between the meteorites is filled with the permanent gases driven out farther afield and having no power to condense. Hence dark metallic and bright gas lines. As time goes on the former must predominate, for the whole swarm of meteorites will then form a gaseous sphere with a strongly heated center, the light of which will be absorbed by the exterior vapor.

The temperature order of the group of stars with bright lines as well as dark ones in their spectra has been traced, and typical stars indicating the chemical changes have been as carefully studied as those in which absorption phenomena are visible alone, so that now there are no breaks in the line connecting the nebulæ with the stars on the verge of extinction.

Here we are brought to another tremendous outcome—that of the evolution of all cosmical bodies from meteorites, the various stages recorded by the spectra being brought about by the various conditions which follow from the conditions.

These are, shortly, that at first collisions produce luminosity among the colliding particles of the swarm, and the permanent gases are given off and fill the interspaces. As condensation goes on, the temperature at the center of condensation always increasing, all the meteorites in time are driven into a state of gas. The meteoritic bombardment prac-

tically now ceases for lack of material, and the future history of the mass of gas is that of a cooling body, the violent motions in the atmosphere while condensation was going on now being replaced by a relative calm.

The absorption phenomena in stellar spectra are not identical at the same mean temperature on the ascending and descending sides of the curve, on account of the tremendous difference in the physical conditions.

In a condensing swarm, the center of which is undergoing meteoritic bombardment from all sides, there cannot be the equivalent of the solar chromosphere; the whole mass is made up of heterogeneous vapor at different temperatures and moving with different velocities in different regions.

In a condensed swarm, of which we can take the sun as a type, all action produced from without has practically ceased; we get relatively a quiet atmosphere and an orderly assortment of the vapors from top to bottom, disturbed only by the fall of condensed metallic vapors. But still, on the view that the differences in the spectra of the heavenly bodies chiefly represent differences in degree of condensation and temperature, there can be *au fond,* no great chemical difference between bodies of increasing and bodies of decreasing temperature. Hence we find at equal mean temperatures on opposite sides of the temperature curve this chemical similarity of the absorbing vapors proved by many points of resemblance in the spectra, especially the identical behavior of the enhanced metallic and cleveite lines.

### CELESTIAL DISSOCIATION

The time you were good enough to put at my disposal is now exhausted, but I cannot conclude without stating that I have not yet exhausted all the conceptions of a high order to which Fraunhofer's apparently useless observation has led us.

The work which to my mind has demonstrated the evolution of the cosmos as we know it from swarms of meteorites, has also suggested a chemical evolution equally majestic in its simplicity.

A quarter of a century ago I pointed out that all the facts then available suggested the hypothesis that in the atmospheres of the sun and stars various degrees of "celestial dissociation" were at work, a "dissociation" which prevented the coming together of the finest particles of matter which at the temperature of the earth and at all arti-

ficial temperature yet attained here compose the metals, the metalloids and compounds.

On this hypothesis the so-called atoms of the chemist represent not the origins of things, but only early stages of the evolutionary process.

At the present time we have tens of thousands of facts which were not available twenty-five years ago. All these go to the support of the hypothesis, and among them I must indicate the results obtained at the last eclipse, dealing with the atmosphere of the sun in relation to that of the various stars of higher temperature to which I called your attention. In this way we can easily explain the enhanced lines of iron existing practically alone in Alpha Cygni. I have yet to learn any other explanation.

I have nothing to take back, either from what I then said or what I have said since on this subject, and although the view is not yet accepted, I am glad to know that many other lines of work which are now being prosecuted tend to favor it.

I have no hesitation in expressing my conviction that in a not distant future the inorganic evolution to which we have been finally led by following up Fraunhofer's useless experiment will take its natural place side by side with that organic evolution, the demonstration of which has been one of the glories of the nineteenth century.

And finally now comes the moral of my address. If I have helped to show that observations having no immediate practical bearing may yet help on the thought of mankind, and that this is a thing worth the doing, let me express a hope that such work shall find no small place in the future University of Birmingham.

# BIOLOGY

IN 1876 WEISMANN brought forward his theory of heredity. This was a step in the doctrine of evolution. It denied the transmission of acquired characters, and did much to explain the process of heredity by the division of the parent cell. Whether or not we accept his thesis that acquired characters are never inherited, great credit is due him for his explanation of heredity. The principles of his theory are given below.

The most important step in biology in the last of the century is the development of the science of bacteriology. In 1849-50 Pollender and Devaine discovered minute bodies in animals that had died of anthrax. They called them bacteria, but did not yet consider them the cause of the disease. At this time the doctrine of spontaneous generation held full sway. Nobody dreamed of asking why wounds gangrened, grapes moulded, wine soured, or like seemingly foolish questions. But about 1857 Pasteur took up the study of fermentation and showed conclusively that its cause is the presence and growth of a micro-organism. Devaine in 1863 re-investigated anthrax from this point of view and showed that such microbes were regularly present in the blood of animals that had died of the disease. In 1865 Pasteur showed that the way to prevent the silkworm disease, then ruining the industry in France, was to destroy everything infected with the microbe which caused the disease. In 1870 Koch of Wollstein took up the subject and invented his method of pure cultivation of the bacteria by cultivating them in a thin layer of jelly between glass plates, picking out species, and thus recultivating and selecting until the product was absolutely of one kind.

Pasteur and Cohn, by a series of the most careful experiments, conducted independently, gave the final blow to the spontaneous generation theory in the early seventies.

Pasteur began applying his method of inoculation about 1876. The first successful experiment was on animals inoculated with anthrax. The uninoculated died; the protected suffered no harm. Inoculation for chicken cholera was also successful. The germ has been found of tuberculosis (Koch, 1882), typhoid fever (Eberth, 1880), diphtheria (Klebs-Loeffier, 1883), cholera (Koch, 1884), lockjaw (Nicholaier, 1884), the grip (Canon, 1892), pneumonia (Frankel, 1886), etc. Pasteur's treatment for hydrophobia, and Behring's antitoxin give great hopes for the ultimate success of inoculation.

## AUGUST WEISMANN

Dr. August Weismann was born Jan. 17, 1834 at Frankfort-on-the-Main, where his father was Professor of Philology in the Lyceum. He studied medicine at Göttingen from 1852 to 1856. He was physician to the Archduke of Austria from 1860 to 1862. For the next ten years he could do no microscopic work on account of his eyesight. He studied Darwin's theory of evolution closely and formed a great admiration for him. In 1876 he published *Studies in the Theory of Descent.* This book commanded a great deal of attention among scientists and in the preface to the English translation of the work Darwin wrote: "At the present time there is hardly any question in biology of more importance than the nature and cause of variability (in individuals)." Since the death of Darwin, Dr. Weismann has developed his theory of descent on purely original lines. It may be said that he conceives the germ-plasm as the basis of heredity. Dr. Weismann denies the transmission to a descendant of any quality, including contagious disease, acquired after birth. He regards sexual reproduction as a stupendous organization, by which nature is ever mixing together and forming new combinations of the hereditary qualities of a whole species. His principles are now accepted by the foremost scientists of Germany, where he has occupied the chair of zoology in Freidburg University since 1862, but in England the heated controversy which arose on the promulgation of his germ-plasm theory is still active.

# THE CONTINUITY OF THE GERM-PLASM AS THE FOUNDATION OF A THEORY OF HEREDITY

## Introduction

When we see that, in the higher organisms, the smallest structural details, and the most minute peculiarities of bodily and mental disposition, are transmitted from one generation to another; when we find in all species of plants and animals a thousand characteristic peculiarities of structure continued unchanged through long series of generations; when we even see them in many cases unchanged throughout whole geological periods; we very naturally ask for the causes of such a strik-the phenomenon: and inquire how it is that such facts become possible, how it is that the individual is able to transmit its structural features to its offspring with such precision. And the immediate answer to such a question must be given in the following terms:—"A single cell out of the millions of diversely differentiated cells which compose the body, becomes specialized as a sexual cell; it is thrown off from the organism and is capable of reproducing all the peculiarities of the parent body, in the new individual which springs from it by cell-division and the complex process of differentiation." Then the more precise question follows: "How is it that such a single cell can reproduce the *tout ensemble* of the parent with all the faithfulness of a portrait?"

The answer is extremely difficult; and no one of the many attempts to solve the problem can be looked upon as satisfactory; no one of them can be regarded as even the beginning of a solution or as a secure foundation from which a complete solution may be expected in the future. Neither Häckel's "Perigenesis of the Plastidule," nor Darwin's "Pangenesis," can be regarded as such a beginning. The former hypothesis does not really treat of that part of the problem which is here placed in the foreground, viz., the explanation of the fact that the tendencies of heredity are present in single cells, but it is rather concerned with the question as to the manner in which it is possible to conceive the transmission of a certain tendency of development into the sexual cell, and ultimately into the organism arising from it. The same may be said of the hypothesis of His, who, like Häckel regards heredity as the transmission of certain kinds of motion. On the other hand, it must be conceded that Darwin's hypothesis goes to the very root of the question,

but he is content to give, as it were, a provisional or purely formal solution, which, as he himself says, does not claim to afford insight into the real phenomena, but only to give us the opportunity of looking at all the facts of heredity from a common standpoint. It has achieved this end, and I believe it has unconsciously done more, in that the thoroughly logical application of its principles has shown that the real causes of heredity cannot lie in the formation of gemmules or in any allied phenomena. The improbabilities to which any such theory would lead are so great that we can affirm with certainty that its details cannot accord with existing facts. Furthermore, Brooks' well-considered and brilliant attempt to modify the theory of Pangenesis cannot escape the reproach that it is based upon possibilities, which one might certainly describe as improbabilities. But although I am of the opinion that the whole foundation of the theory of Pangenesis, however it may be modified, must be abandoned, I think, nevertheless, its author deserves great credit, and that its production has been one of those indirect roads along which science has been compelled to travel in order to arrive at the truth. Pangenesis is a modern revival of the oldest theory of heredity, that of Democritus, according to which the sperm is secreted from all parts of the body of both sexes during copulation, and is animated by a bodily force; according to this theory also, the sperm from each part of the body reproduces the same part.

If, according to the received physiological and morphological ideas of the day, it is impossible to imagine that gemmules produced by each cell of the organism are at all times to be found in all parts of the body, and furthermore that these gemmules are collected in the sexual cells, which are then able to again reproduce in a certain order each separate cell of the organism, so that each sexual cell is capable of developing into the likeness of the parent body; if all this is inconceivable, we must inquire for some other way in which we can arrive at a foundation for the true understanding of heredity. My present task is not to deal with the whole question of heredity, but only with the single although fundamental question—"How is it that a single cell of the body can contain within itself all the hereditary tendencies of the whole organism?" I am here leaving out of account the further question as to the forces and the mechanism by which these tendencies are developed in the building-up of the organism. On this account I abstain from considering at present the views of Nägeli, for as will be shown later on, they only slightly touch this fundamental question, although they may certainly

claim to be of the highest importance with respect to the further question alluded to above.

Now if it is impossible for the germ-cell to be, as it were, an extract of the whole body, and for all the cells of the organism to dispatch small particles to the germ-cells, from which the latter derive their power of heredity; then there remain, as it seems to me, only two other possible, physiologically conceivable, theories as to the origin of germ-cells, manifesting such powers as we know they possess. Either the substance of the parent germ-cell is capable of undergoing a series of changes which, after the building-up of a new individual leads back again to identical germ-cells; or the germ-cells are not derived at all, as far as their essential and characteristic substance is concerned, from the body of the individual, but they are derived directly from the parent germ-cell.

I believe that the latter view is the true one: I have expounded it for a number of years, and have attempted to defend it, and to work out its further details in various publications. I propose to call it the theory of "The Continuity of the Germ-plasm," for it is founded upon the idea that heredity is brought about by the transference from one generation to another of a substance with a definite chemical, and above all, molecular constitution. I have called this substance "germ-plasm," and have assumed that it possesses a highly complex structure, conferring upon it the power of developing into a complex organism. I have attempted to explain heredity by supposing that in each ontogeny a part of the specific germ-plasm contained in the parent egg-cell is not used up in the construction of the body of the offspring, but is reserved unchanged for the formation of the germ-cells of the following generation.

It is clear that this view of the origin of germ-cells explains the phenomena of heredity very simply, inasmuch as heredity becomes thus a question of growth and of assimilation,—the most fundamental of all vital phenomena. If the germ-cells of successive generations are directly continuous, and thus only form, as it were, different parts of the same substance, it follows that these cells must, or at any rate may, possess the same molecular constitution, and that they would therefore pass through exactly the same stages under certain conditions of development, and would form the same final product. The hypothesis of the continuity of the germ-plasm gives an identical starting point to each successive generation, and thus explains how it is that an identical product arises from all of them. In other words, the hypothesis explains heredity as part of the underlying problems of assimilation and of the

causes which act directly during ontogeny; it therefore builds a foundation from which the explanation of these phenomena can be attempted.

It is true that this theory also meets with difficulties, for it seems to be unable to do justice to a certain class of phenomena, viz., the transmission of so-called acquired characters. I therefore gave immediate and special attention to this point in my first publication on heredity, and I believe that I have shown that the hypothesis of the transmission of acquired characters—up to that time generally accepted—is, to say the least, very far from being proved, and that entire classes of facts which have been interpreted under this hypothesis may be quite as well interpreted otherwise, while in many cases they must be explained differently. I have shown that there is no ascertained fact which, at least up to the present time, remains in irrevocable conflict with the hypothesis of the continuity of the germ-plasm; and I do not know any reason why I should modify this opinion to-day, for I have not heard of any objection which appears to be feasible. E. Roth has objected that in pathology we everywhere meet with the fact that acquired local disease may be transmitted to the offspring as a predisposition; but all such cases are exposed to the serious criticism that the very point that first needs to be placed on a secure footing is incapable of proof, viz., the hypothesis that the causes which in each particular case led to the predisposition were really acquired. It is not my intention, on the present occasion, to enter fully into the question of acquired characters; I hope to be able to consider the subject in greater detail at a future date. But in the meantime I should wish to point out that we ought, above all, to be clear as to what we really mean by the expression "acquired character." An organism cannot acquire anything unless it already possesses the predisposition to acquire it: acquired characters are therefore no more than local or sometimes general variations which arise under the stimulus provided by certain external influences. If by the long-continued handling of a rifle, the so-called "*Exercierknochen*" (a bony growth caused by the pressure of the weapon in drilling) is developed, such a result depends upon the fact that the bone in question, like every other bone, contains within itself a predisposition to react upon certain mechanical stimuli, by growth in a certain direction and to a certain extent. The predisposition towards an "*Exercierknochen*" is therefore already present, or else the growth could not be formed; and the same reasoning applies to all other "acquired characters."

Nothing can arise in an organism unless the predisposition to it is

pre-existent, for every acquired character is simply the reaction of the organism upon a certain stimulus. Hence I should never have thought of asserting that predispositions cannot be transmitted, as E. Roth appears to believe. For instance, I freely admit that the predisposition to an "*Exercierknochen*" varies, and that a strongly marked predisposition may be transmitted from father to son, in the form of bony tissue with a more susceptible constitution. But I should deny that the son could develop an "*Exercierknochen*" without having drilled, or that, after having drilled, he could develop it more easily than his father, on account of the drilling through which the latter first acquired it. I believe that this is as impossible as that the leaf of an oak should produce a gall without having been pierced by a gall-producing insect, as a result of the thousands of antecedent generations of oaks which have been pierced by such insects, and have thus "acquired" the power of producing galls. I am also far from asserting that the germ-plasm—which, as I hold, is transmitted as the basis of heredity from one generation to another—is absolutely unchangeable or totally uninfluenced by forces residing in the organism within which it is transformed into germ-cells. I am also compelled to admit that it is conceivable that organisms may exert a modifying influence upon their germ-cells, and even that such a process is to a certain extent inevitable. The nutrition and growth of the individual must exercise some influence upon its germ-cells; but in the first place this influence must be extremely slight, and in the second place it cannot act in the manner in which it is usually assumed that it takes place. A change of growth at the periphery of an organism, as in the case of an "*Exercierknochen*," can never cause such a change in the molecular structure of the germ-plasm as would augment the predisposition to an "*Exercierknochen*," so that the son would inherit an increased susceptibility of the bony tissue or even of the particular bone in question. But any change produced will result from the reaction of the germ-cell upon changes of nutrition caused by alteration in growth at the periphery, leading to some change in the size, number, or arrangement of its molecular units. In the present state of our knowledge there is reason for doubting whether such reaction can occur at all; but, if it can take place, at all events the quality of the change in the germ-plasm can have nothing to do with the quality of the acquired character, but only with the way in which the general nutrition is influenced by the latter. In the case of the "*Exercierknochen*" there would be practically no change in the general nutrition, but if such a bony

growth could reach the size of a carcinoma, it is conceivable that a disturbance of the general nutrition of the body might ensue. Certain experiments on plants—on which Nägeli showed that they can be submitted to strongly varied conditions of nutrition for several generations, without the production of any visible hereditary change—show that the influence of nutrition upon the germ-cells must be very slight, and that it may possibly leave the molecular structure of the germ-plasm altogether untouched. This conclusion is also supported by comparing the uncertainty of these results with the remarkable precision with which heredity acts in the case of those characters which are known to be transmitted. In fact, up to the present time, it has never been proved that any changes in general nutrition can modify the molecular structure of the germ-plasm, and far less has it been rendered by any means probable that the germ-cells can be affected by acquired changes which have no influence on general nutrition. If we consider that each so-called predisposition (that is, a power of reacting upon a certain stimulus in a certain way, possessed by any organism or by one of its parts) must be innate, and further that each acquired character is only the predisposed reaction of some part of an organism upon some external influence; then we must admit that only one of the causes which produce any acquired character can be transmitted, the one which was present before the character itself appeared, viz., the predisposition; and we must further admit that the latter arises from the germ, and that it is quite immaterial to the following generation whether such predisposition comes into operation or not. The continuity of the germ-plasm is amply sufficient to account for such a phenomenon, and I do not believe that any objection to my hypothesis, founded upon the actually observed phenomena of heredity, will be found to hold. If it be accepted, many facts will appear in a light different from that which has been cast upon them by the hypothesis which has been hitherto received,—a hypothesis which assumes that the organism produces germ-cells afresh, again and again, and that it produces them entirely from its own substance. Under the former theory the germ-cells are no longer looked upon as the product of the parent's body, at least as far as their essential part—the specific germ-plasm—is concerned: they are rather considered as something which is to be placed in contrast with the *tout ensemble* of the cells which make up the parent's body, and the germ-cells of succeeding generations stand in a similar relation to one another as a series of generations of unicellular organisms, arising by a continued process of cell-division. It

is true that in most cases the generations of germ-cells do not arise immediately from one another as complete cells, but only as minute particles of germ-plasm. This latter substance, however, forms the foundation of the germ-cells of the next generation, and stamps them with their specific character. Previous to the publication of my theory, C. Jäger, and later M. Nussbaum, have expressed ideas upon heredity which come very near to my own. Both of these writers started with the hypothesis that there must be a direct connection between the germ-cells of succeeding generations, and they tried to establish such a continuity by supposing that the germ-cells of the offspring are separated from the parent germ-cell before the beginning of embryonic development, or at least before any histological differentiation has taken place. In this form their suggestion cannot be maintained, for it is in conflict with numerous facts. A continuity of the germ-cells does not now take place, except in very rare instances; but this fact does not prevent us from adopting a theory of the continuity of the germ-plasm, in favour of which much weighty evidence can be brought forward. In the following pages I shall attempt to develop further the theory of which I have just given a short account, to defend it against any objections which have been brought forward, and to draw from it new conclusions which may perhaps enable us more thoroughly to appreciate facts which are known, but imperfectly understood. It seems to me that this theory of the continuity of the germ-plasm deserves at least to be examined in all its details, for it is the simplest theory upon the subject, and the one which is most obviously suggested by the facts of the case, and we shall not be justified in forsaking it for a more complex theory until proof that it can be no longer maintained is forthcoming. It does not presuppose anything except facts which can be observed at any moment, although they may not be understood,—such as assimilation, or the development of like organisms from like germs; while every other theory of heredity is founded on hypotheses which cannot be proved. It is nevertheless possible that continuity of the germ-plasm does not exist in the manner in which I imagine that it takes place, for no one can at present decide whether all the ascertained facts agree with and can be explained by it. Moreover, the ceaseless activity of research brings to light new facts every day, and I am far from maintaining that my theory may not be disproved by some of these. But even if it should have to be abandoned at a later period, it seems to me that, at the present time, it is a necessary stage in the advancement of our knowledge, and

one which must be brought forward and passed through, whether it prove right or wrong, in the future. In this spirit I offer the following considerations, and it is in this spirit that I should wish them to be received.

## I. The Germ-plasm

I entirely agree with Strasburger when he says, "The specific qualities of organisms are based upon nuclei;" and I further agree with him in many of his ideas as to the relation between the nucleus and cell-body: "Molecular stimuli proceed from the nucleus into the surrounding cytoplasm; stimuli which, on the one hand, control the phenomena of assimilation in the cell, and, on the other hand, give to the growth of the cytoplasm, which depends upon nutrition, a certain character peculiar to the species." "The nutritive cytoplasm assimilates, while the nucleus controls the assimilation, and hence the substances assimilated possess a certain constitution and nourish in a certain manner the cyto-idioplasm and the nuclear idioplasm. In this way the cytoplasm takes part in the phenomena of construction, upon which the specific form of the organism depends. This constructive activity of the cyto-idioplasm depends upon the regulative influence of the nuclei." The nuclei therefore "determine the specific direction in which an organism develops."

The opinion—derived from the recent study of the phenomena of fertilization—that the nucleus impresses its specific character upon the cell, has received conclusive and important confirmation in the experiments upon the regeneration of Infusoria, conducted simultaneously by M. Nussbaum at Bonn, and by A. Gruber at Freiburg. Nussbaum's statement that an artificially separated portion of a *Paramaecium*, which does not contain any nuclear substance, immediately dies, must not be accepted as of general application, for Gruber has kept similar fragments of other Infusoria alive for several days. Moreover, Gruber had previously shown that individual Protozoa occur, which live in a normal manner, and are yet without a nucleus, although this structure is present in other individuals of the same species. But the meaning of the nucleus is made clear by the fact, published by Gruber, that such artificially separated fragments of Infusoria are incapable of regeneration, while on the other hand those fragments which contain nuclei always regenerate. It is therefore only under the influence of the nucleus that the cell substance re-develops into the full type of the species. In adopting the view that the nucleus is the factor which deter-

mines the specific nature of the cell, we stand on a firm foundation upon which we can build with security.

If therefore the first segmentation nucleus contains, in its molecular structure, the whole of the inherited tendencies of development, it must follow that during segmentation and subsequent cell-division, the nucleoplasm will enter upon definite and varied changes which must cause the differences appearing in the cells which are produced; for identical cell-bodies depend, *ceteris paribus,* upon identical nucleoplasm, and conversely different cells depend upon differences in the nucleoplasm. The fact that the embryo grows more strongly in one direction than in another, that its cell-layers are of different nature and are ultimately differentiated into various organs and tissues,—forces us to accept the conclusion that the nuclear substance has also been changed in nature, and that such changes take place during ontogenetic development in a regular and definite manner. This view is also held by Strasburger, and it must be the opinion of all who seek to derive the development of inherited tendencies from the molecular structure of the germ-plasm, instead of from preformed gemmules.

We are thus led to the important question as to the forces by which the determining substance or nucleoplasm is changed, and as to the manner in which it changes during the course of ontogeny, and on the answer to this question our further conclusions must depend. The simplest hypothesis would be to suppose that, at each division of the nucleus, its specific substance divides into two halves of unequal quality, so that the cell-bodies would also be transformed; for we have seen that the character of a cell is determined by that of its nucleus. Thus in any Metazoon the first two segmentation spheres would be transformed in such a manner that one only contained the hereditary tendencies of the endoderm and the other those of the ectoderm, and therefore, at a later stage, the cells of the endoderm would arise from the one and those of the ectoderm from the other; and this is actually known to occur. In the course of further division the nucleoplasm of the first ectoderm cell would again divide unequally, *e. g.,* into the nucleoplasm containing the hereditary tendencies of the nervous system, and into that containing the tendencies of the external skin. But even then, the end of the unequal division of nuclei would not have been nearly reached; for, in the formation of the nervous system, the nuclear substance which contains the hereditary tendencies of the sense-organs would, in the course of further cell-division, be separated from that

which contains the tendencies of the central organs, and the same process would continue in the formation of all single organs, and in the final development of the most minute histological elements. This process would take place in a definitely ordered course, exactly as it has taken place throughout a very long series of ancestors; and the determining and directing factor is simply and solely the nuclear substance, the nucleoplasm, which possesses such a molecular structure in the germ-cell that all such succeeding stages of its molecular structure in future nuclei must necessarily arise from it, as soon as the requisite external conditions are present. This is almost the same conception of ontogenetic development as that which has been held by embryologists who have not accepted the doctrine of evolution: for we have only to transfer the primary cause of development, from an unknown source within the organism, into the nuclear substance, in order to make the views identical.

I believe I have shown that theoretically hardly any objections can be raised against the view that the nuclear substance of somatic cells may contain unchanged germ-plasm, or that this germ-plasm may be transmitted along certain lines. It is true that we might imagine *a priori* that all somatic nuclei contain a small amount of unchanged germ-plasm. In Hydroids such an assumption cannot be made, because only certain cells in a certain succession possess the power of developing into germ-cells; but it might well be imagined that in some organisms it
e a great advantage if every part possessed the power of grow-
into the whole organism and of producing sexual cells under
ate circumstances. Such cases might exist if it were possible
omatic nuclei to contain a minute fraction of unchanged germ-
For this reason, Strasburger's other objection against my theory
s to hold; viz., that certain plants can be propagated by pieces
nes, roots, or even by means of leaves, and that plants produced
nanner may finally give rise to flowers, fruit and seeds, from
ew plants arise. "It is easy to grow new plants from the leaves
nia which have been cut off and merely laid upon moist sand,
in the normal course of ontogeny the molecules of germ-plasm
ot have been compelled to pass through the leaf; and they ought
e to be absent from its tissue. Since it is possible to raise from
a plant which produces flower and fruit, it is perfectly certain
cial cells containing the germ substance cannot exist in the

plant." But I think that this fact only proves that in begonia and similar plants all the cells of the leaves or perhaps only certain cells contain a small amount of germ-plasm, and that consequently these plants are specially adapted for propagation by leaves. How is it then that all plants cannot be reproduced in this way? No one has ever grown a tree from the leaf of the lime or oak, or a flowering plant from the leaf of the tulip or convolvulus. It is insufficient to reply that in the last mentioned cases the leaves are more strongly specialized, and have thus become unable to produce germ-substance; for the leaf-cells in these different plants have hardly undergone histological differentiation in different degrees. If, notwithstanding, the one can produce a flowering plant, while the others have not this power, it is of course clear that reasons other than the degree of histological differentiation must exist; and, according to my opinion, such a reason is to be found in the admixture of a minute quantity of unchanged germ-plasm with some of their nuclei.

In Sach's excellent lectures on the physiology of plants, we read on page 723—"In the true mosses almost any cell of the roots, leaves and shoot-axes, and even of the immature sporogonium, may grow out under favourable conditions, become rooted, form new shoots, and give rise to an independent living plant." Since such plants produce germ-cells at a later period, we have here a case which requires the assumption that all or nearly all cells must contain germ-plasm.

The theory of the continuity of the germ-plasm seems to me to be still less disproved or even rendered improbable by the facts of the alternation of generations. If the germ-plasm may pass on from the egg into certain somatic cells of an individual, and if it can be further transmitted along certain lines, there is no difficulty in supposing that it may be transmitted through a second, third, or through any number of individuals produced from the former by budding. In fact, in the Hydroids, on which my theory of the continuity of the germ-plasm has been chiefly based, alternation of generations is the most important means of propagation.

## II. The Significance of the Polar Bodies

We have already seen that the specific nature of a cell depends upon the molecular structure of its nucleus; and it follows from this conclusion that my theory is further, and as I believe strongly, supported, by the phenomenon of the expulsion of polar bodies, which has remained inexplicable for so long a time.

For if the specific molecular structure of a cell-body is caused and determined by the structure of the nucleoplasm, every kind of cell which is histologically differentiated must have a specific nucleoplasm. But the egg-cell of most animals, at any rate during the period of growth, is by no means an indifferent cell of the most primitive type. At such a period its cell-body has to perform quite peculiar and specific functions; it has to secrete nutritive substances of a certain chemical nature and physical constitution, and to store up this food material in such a manner that it may be at the disposal of the embryo during its development. In most cases the egg-cell also forms membranes which are often characteristic of particular species of animals. The growing egg-cell is therefore histologically differentiated: and in this respect resembles a somatic cell. It may perhaps be compared to a gland-cell, which does not expel its secretion, but deposits it within its own substance. To perform such specific functions it requires a specific cell-body, and the latter depends upon a specific nucleus. It therefore follows that the growing egg-cell must possess nucleoplasm of specific molecular structure, which directs the above mentioned secretory functions of the cell. The nucleoplasm of histologically differentiated cells may be called histogenetic nucleoplasm, and the growing egg-cell must contain such a substance, and even a certain specific modification of it. This nucleoplasm cannot possibly be the same as that which, at a later period, causes embryonic development. Such development can only be produced by true germ-plasm of immensely complex constitution, such as I have previously attempted to describe. It therefore follows that the nucleus of the egg-cell contains two kind of nucleoplasm:—germ-plasm and a peculiar modification of histogenetic nucleoplasm, which may be called ovogenetic nucleoplasm. This substance must greatly preponderate in the young egg-cell, for, as we have already seen, it controls the growth of the latter. The germ-plasm, on the other hand, can only be present in minute quantity at first, but it must undergo considerable increase during the growth of the cell. But in order that the germ-plasm may control the cell-body, or, in other words, in order that embryonic development may begin, the still preponderating ovogenetic nucleoplasm must be removed from the cell. This removal takes place in the same manner as that in which differing nuclear substances are separated during the ontogeny of the embryo: viz., by nuclear division, leading to cell-division. The expulsion of the polar bodies is nothing more than the removal of ovogenetic nucleoplasm from the egg-cell. That the ovogenetic nucleoplasm continues to

greatly preponderate in the nucleus up to the very last, may be concluded from the fact that two successive divisions of the latter and the expulsion of two polar bodies appear to be the rule. If in this way a small part of the cell-body is expelled from the egg, the extrusion must in all probability be considered as an inevitable loss, without which the removal of the ovogenetic neucloplasm cannot be effected.

### III. On the Nature of Parthenogenesis

It is well known that the formation of polar bodies has been repeatedly connected with the sexuality of germ-cells, and that it has been employed to explain the phenomena of parthenogenesis. I may now perhaps be allowed to develop the views as to the nature of parthenogenesis at which I have arrived under the influence of my explanation of polar bodies.

The theory of parthenogenesis adopted by Minot and Balfour is distinguished by its simplicity and clearness, among all other interpretations which had been hitherto offered. Indeed, their explanation follows naturally and almost as a matter of course, if the assumption made by these observers be correct, that the polar body is the male part of the hermaphrodite egg-cell. An egg which has lost its male part cannot develop into an embryo until it has received a new male part in fertilization. On the other hand, an egg which does not expel its male part may develop without fertilization, and thus we are led to the obvious conclusion that parthenogenesis is based upon the non-expulsion of polar bodies. Balfour distinctly states "that the function of forming polar cells has been acquired by the ovum for the express purpose of preventing parthenogenesis."

It is obvious that I cannot share this opinion, for I regard the expulsion of polar bodies as merely the removal of the ovogenetic nucleoplasm, on which depended the development of the specific histological structure of the egg-cell. I must assume that the phenomena of maturation in the parthenogenetic egg and in the sexual egg are precisely identical, and that in both, the ovogenetic nucleoplasm must in some way be removed before embryonic development can begin.

Unfortunately the actual proof of this assumption is not so complete as might be desired. In the first place, we are as yet uncertain whether polar bodies are or are not expelled by parthenogenetic eggs; for in no single instance has such expulsion been established beyond doubt. It is true that this deficiency does not afford any support to the

explanation of Minot and Balfour, for in all cases in which polar bodies have not been found in parthenogenetic eggs, these structures are also absent from the eggs which require fertilization in the same species. But although the expulsion of polar bodies in parthenogenesis has not yet been proved to occur, we must assume it to be nearly certain that the phenomena of maturation, whether connected or unconnected with the expulsion of polar bodies, are the same in the eggs which develop parthenogenetically and in those which are capable of fertilization, in one and the same species. This conclusion depends, above all, upon the phenomena of reproduction in bees, in which, as a matter of fact, the same egg may be fertilized or may develop parthenogenetically, as I shall have occasion to describe in greater detail at a later period.

Hence when we see that the eggs of many animals are capable of developing without fertilization, while in other animals such development is impossible, the difference between the two kinds of eggs must rest upon something more than the mode of transformation of the nucleus of the germ-cell into the first segmentation nucleus. There are, indeed, facts which distinctly point to the conclusion that the difference is based upon quantitative and not qualitative relations. A large number of insects are exceptionally reproduced by the parthenogenetic method, *e. g.*, in Lepidoptera. Such development does not take place in all the eggs laid by an unfertilized female, but only in part, and generally a small fraction of the whole, while the rest die. But among the latter there are some which enter upon embryonic development without being able to complete it, and the stage at which development may cease also varies. It is also known that the eggs of higher animals may pass through the first stages of segmentation without having been fertilized. This was shown to be the case in the egg of the frog by Leuckart, in that of the fowl by Oellacher, and even in the egg of mammals by Hensen.

Hence in sı ch cases it is not the impulse to development, but the power to complete it, which is absent. We know that force is always bound up with matter, and it seems to me that such instances are best explained by the supposition that too small an amount of that form of matter is present, which, by its controlling agency, effects the building up of the embryo by the transformation of mere nutritive material. This substance is the germ-plasm of the segmentation nucleus, and I have assumed above that it is altered in the course of ontogeny by changes which arise from within, so that when sufficient nourishment is afforded by the cell-body, each succeeding stage necessarily results from the pre-

ceding one. I believe that changes arise in the constitution of the nucleoplasm at each cell-division which takes place during the building up of the embryo, changes which either correspond or differ in the two halves of each nucleus. If, for the present, we neglect the minute amount of unchanged germ-plasm which is reserved for the formation of the germ-cells, it is clear that a great many different stages in the development of somatic nucleoplasm are thus formed, which may be denominated as stages 1, 2, 3, 4, etc., up to *n*. In each of these stages the cells differ more as development proceeds, and as the number by which the stage is denominated becomes higher. Thus, for instance, the two first segmentation spheres would represent the first stage of somatic nucleoplasm, a stage which may be considered as but slightly different in its molecular structure from the nucleoplasm of the segmentation nucleus; the first four segmentation spheres would represent the second stage; the succeeding eight spheres the third, and so on. It is clear that at each successive stage the molecular structure of the nucleoplasm must be further removed from that of the germ-plasm, and that, at the same time, the cells of each successive stage must also diverge more widely among themselves in the molecular structure of their nucleoplasm. Early in development each cell must possess its own peculiar nucleoplasm, for the further course of development is peculiar to each cell. It is only in the later stages that equivalent or nearly equivalent cells are formed in large numbers, cells in which we must also suppose the existence of equivalent nucleoplasm.

If we may assume that a certain amount of germ-plasm must be contained in the segmentation nucleus in order to complete the whole process of the ontogenetic differentiation of this substance; if we may further assume that the quantity of germ-plasm in the segmentation nucleus varies in different cases; then we should be able to understand why one egg can only develop after fertilization, while another can begin its development without fertilization, but cannot finish it, and why a third is even able to complete its development. We should also understand why one egg only passes through the first stages of segmentation and is then arrested, while another reaches a few more stages in advance, and a third develops so far that the embryo is nearly completely formed. These differences would depend upon the extent to which the germ-plasm, originally present in the egg, was sufficient for the development of the latter; development will be arrested as soon as the nucleoplasm is no longer capable of producing the succeeding stage, and is thus unable to enter upon the following nuclear division.

From a general point of view such a theory would explain many difficulties, and it would render possible an explanation of the phyletic origin of parthenogenesis, and an adequate understanding of the strange and often apparently abrupt and arbitrary manner of its occurrence. In my works on Daphnidae I have already laid especial stress upon the proposition that parthenogenesis in insects and Crustacea certainly cannot be an ancestral condition which has been transmitted by heredity, but that it has been derived from a sexual condition. In what other way can we explain the fact that parthenogenesis is present in certain species or genera, but absent in others closely allied to them; or the fact that males are entirely wanting in species of which the females possess a complete apparatus for fertilization? I will not repeat all the arguments with which I attempted to support this conclusion. Such a conclusion may be almost certainly accepted for the Daphnidae, because parthenogenesis does not occur in their still living ancestors, the Phyllopods, and especially the Estheridae. In Daphnidae the cause and object of the phyletic development of parthenogenesis may be traced more clearly than in any other group of animals. In Daphnidae we can accept the conclusion with greater certainty than in all other groups, except perhaps the Aphidae, that parthenogenesis is extremely advantageous to species in certain conditions of life; and that it has only been adopted when, and as far as, it has been beneficial; and further, that at least in this group parthenogenesis became possible and was adopted in each species as soon as it became useful. Such a result can be easily understood if it is only the presence of more or less germ-plasm which decides whether an egg is or is not capable of development without fertilization.

If we now examine the foundations of this hypothesis we shall find that we may at once accept one of its assumptions, viz., that fluctuations occur in the quantity of germ-plasm in the segmentation nucleus; for there can never be absolute equality in any single part of different individuals. As soon therefore as these fluctuations become so great that parthenogenesis is produced, it may become, by the operation of natural selection, the chief mode of reproduction of the species or of certain generations of the species. In order to place this theory upon a firm basis, we have simply to decide whether the quantity of germ-plasm contained in the segmentation nucleus is the factor which determines development; although for the present it will be sufficient if we can render this view to some extent probable, and show that it is not in contradiction with established facts.

At first sight this hypothesis seems to encounter serious difficulties. It will be objected that neither the beginning nor the end of embryonic development can possibly depend upon the quantity of nucleoplasm in the segmentation nucleus, since the amount may be continually increased by growth; for it is well known that during embryonic development the nuclear substance increases with astonishing rapidity. By an approximate calculation I found that in the egg of a Cynips the quantity of nuclear substance present at the time when the blastoderm was about to be formed, and when there were twenty-six nuclei, was even then seven times as great as the quantity which had been contained in the segmentation nucleus. How then can we imagine that embryonic development would ever be arrested from want of nuclear substance, and if such deficiency really acted as an arresting force, how then could development begin at all? We might suppose that when germ-plasm is present in sufficient quantity to start segmentation, it must also be sufficient to complete the development; for it grows continuously, and must presumably always possess a power equal to that which it possessed at the beginning, and which was just sufficient to start the process of segmentation. If at each ontogenetic stage the quantity of nucleoplasm is just sufficient to produce the following stage, we might well imagine that the whole ontogeny would necessarily be completed.

The flaw in this argument lies in the erroneous assumption that the growth of nuclear substance is, when the quality of the nucleus and the conditions of nutrition are equal, unlimited and uncontrolled. The intensity of growth must depend upon the quantity of nuclear substance with which growth and the phenomena of segmentation commenced. There must be an optimum quantity of nucleoplasm with which the growth of the nucleus proceeds most favourably and rapidly, and this optimum will be represented in the normal size of the segmentation nucleus. Such a size is just sufficient to produce, in a certain time and under certain external conditions, the nuclear substance necessary for the construction of the embryo, and to start the long series of cell-divisions. When the segmentation nucleus is smaller, but large enough to enter upon segmentation, the nuclei of the two first embryonic cells will fall rather more below the normal size, because the growth of the segmentation nucleus, during and after division will be less rapid on account of its unusually small size. The succeeding generations of nuclei will depart more and more from the normal size in each respective stage, because they do not pass into a resting stage during embryonic

development, but divide again immediately after their formation. Hence nuclear growth would become less vigorous as the nuclei fell more and more below the optimum size, and at last a moment would arrive when they would be unable to divide, or would be at least unable to control the cell-body in such a manner as to lead to its division.

The first event of importance for embryonic development is the maturation of the egg, *i. e.*, the transformation of the nucleus of the germ-cell into a nuclear spindle and the removal of the ovogenetic nucleoplasm by the separation of polar bodies, or by some analogous process. There must be some cause for this separation, and I have already tried to show that it may lie in the quantitative relations which obtain between the two kinds of nucleoplasm contained in the nucleus of the egg. I have suggested that the germ-plasm, at first small in quantity, undergoes a gradual increase, so that it can finally oppose the ovogenetic nucleoplasm. I will not further elaborate this suggestion, for the ascertained facts are insufficient for the purpose. But the appearances witnessed in nuclear division indicate that there are opposing forces, and that such a contest is the motive cause of division; and Roux may be right in referring the opposition to electrical forces. However this may be, it is perfectly certain that the development of this opposition is based upon internal conditions arising during growth in the nucleus itself. The quantity of nuclear thread cannot by itself determine whether the nucleus can or cannot enter upon division; if so, it would be impossible for two divisions to follow each other in rapid succession, as is actually the case in the separation of the two polar bodies, and also in their subsequent division. In addition to the effects of quantity, the internal conditions of the nucleus must also play an important part in these phenomena. Quantity alone does not necessarily produce nuclear division, or the nucleus of the egg would divide long before maturation is complete, for it contains much more nucleoplasm than the female pronucleus, which remains in the egg after the expulsion of the polar bodies, and which is in most cases incapable of further division. But the fact that segmentation begins immediately after the conjugation of male and female pronuclei, also shows that quantity is an essential requisite. The effect of fertilization has been represented as analogous to that of the spark which kindles the gunpowder. In the latter case an explosion ensues, in the former segmentation begins. Even now many authorities are inclined to refer the polar repulsion manifested in the nuclear division which immediately follows

fertilization, to the antagonism between male and female elements. But, according to the important discoveries of Flemming and van Beneden, the polar repulsion in each nuclear division is not based on the antagonism between male and female loops, but depends upon the antagonism and mutual repulsion between the two halves of the same loop. The loops of the father and those of the mother remain together and divide together throughout the whole ontogeny.

What can be the explanation of the fact that nuclear division follows immediately after fertilization, but that without fertilization it does not occur in most cases? There is only one possible explanation, viz., the fact that the quantity of the nucleus has been suddenly doubled, as the result of conjugation. The difference between the male and female pronuclei cannot serve as an explanation, even though the nature of this difference is entirely unknown, because polar repulsion is not developed between the male and female halves of the nucleus, but within each male and each female half. We are thus forced to conclude that increase in the quantity of the nucleus affords an impulse for division, the disposition towards it being already present. It seems to me that this view does not encounter any theoretical difficulties, and that it is an entirely feasible hypothesis to suppose that, besides the internal conditions of the nucleus, its quantitative relation to the cell-body must be taken into especial account. It is imaginable, or perhaps even probable, that the nucleus enters upon division as soon as its idioplasm has attained a certain strength, quite apart from the supposition that certain internal conditions are necessary for this end. As above stated, such conditions may be present, but division may not occur because the right quantitative relation between nucleus and cell-body, or between the different kinds of nuclear idioplasm has not been established. I imagine that such a quantitative deficiency exists in an egg which, after the expulsion of the ovogenetic nucleoplasm in the polar bodies, requires fertilization in order to begin segmentation. The fact that the polar bodies were expelled proves that the quantity of the nucleus was sufficient to cause division, while afterwards it was no longer sufficient to produce such a result.

This suggestion will be made still clearer by an example. In *Ascaris megalocephala* the nuclear substance of the female pronucleus forms two loops, and the male pronucleus does the same; hence the segmentation nucleus contains four loops, and this is also the case with the first segmentation spheres. If we suppose that in embryonic develop-

ment the first nuclear division requires such an amount of nuclear substance as is necessary for the formation of four loops,—it follows that an egg, which can only form two or three loops from its nuclear reticulum, would not be able to develop parthenogenetically, and that not even the first division would take place. If we further suppose that, while four loops are sufficient to start nuclear division, these loops must be of a certain size and quantity in order to complete the whole ontogeny (in a certain species), it follows that eggs possessing a reticulum which contains barely enough nuclear substance to divide into four segments, would be able to produce the first division and perhaps also the second and third, or some later division, but that at a certain point during ontogeny, the nuclear substance would become insufficient, and development would be arrested. This will occur in eggs which enter upon development without fertilization, but are arrested before its completion. One might compare this retardation leading to the final arrest of development, to a railway train which is intended to meet a number of other trains at various junctions, and which can only travel slowly because of some defect in the engine. It will be a little behind time at the first junction, but it may just catch the train, and it may also catch the second or even the third; but it will be later at each successive junction, and will finally arrive too late for a certain train; and after that it will miss all the trains at the remaining junctions. The nuclear substance grows continuously during development, but the rate at which it increases depends upon the nutritive conditions together with its initial quantity. The nutritive changes during the development of an egg depend upon the quantity of the cell-body which was present at the outset, and which cannot be increased. If the quantity of the nuclear substance is rather too small at the beginning, it will become more and more insufficient in succeeding stages, as its growth becomes less vigorous, and differs more from the standard it would have reached if the original quantity had been normal. Consequently it will gradually fall more and more short of the normal quantity, like the train which arrives later and later at each successive junction, because its engine, although with the full pressure of steam, is unable to attain the normal speed.

It will be objected that four loops cannot be necessary for nuclear division in *Ascaris*, since such division takes place in the formation of the polar bodies, resulting in the appearance of the female pronucleus with only two loops. But this fact only shows that the quantity of nuclear substance necessary for the formation of four loops is not neces-

sary for all nuclear divisions; it does not disprove the assumption that such a quantity is required for the division of the segmentation nucleus. In addition to these considerations we must not leave the substance of the cell-body altogether out of account, for, although it is not the bearer of the tendencies of heredity, it must be necessary for every change undergone by the nucleus, and it surely also possesses the power of influencing changes to a large extent. There must be some reason for the fact that in all animal eggs with which we are acquainted, the nucleus moves to the surface of the egg at the time of maturation, and there passes through its well known transformation. It is obvious that it is there subjected to different influences from those which would have acted upon it in the center of the cell-body, and it is clear that such an unequal cell-division as takes place in the separation of the polar bodies could not occur if the nucleus remained in the center of the egg.

This explanation of the necessity for fertilization does not exclude the possibility that, under certain circumstances, the substance of the egg-nucleus may be larger, so that it is capable of forming four loops. Eggs which thus possess sufficient nucleoplasm, viz., germ-plasm, for the formation of the requisite four loops of normal size (namely, of the size which would have been produced by fertilization), can and must develop by the parthenogenetic method.

Of course the assumption that four loops must be formed has only been made for the sake of illustration. We do not yet know whether there are always exactly four loops in the segmentation nucleus. I may add that, although the details by which these considerations are illustrated are based on arbitrary assumptions, the fundamental view that the development of the egg depends, *ceteris paribus,* upon the quantity of nuclear substance, is certainly right, and follows as a necessary conclusion from the ascertained facts. It is not unlikely that such a view may receive direct proof in the results of future investigations. Such proof might, for instance, be forthcoming if we were to ascertain, in the same species, the number of loops present in the segmentation nucleus of fertilization, as compared with those present in the segmentation nucleus of parthenogenesis.

The reproductive process in bees will perhaps be used as an argument against my theory. In these insects the same egg will develop into a female or male individual, according as fertilization has or has not taken place, respectively. Hence one and the same egg is capable of fertilization, and also of parthenogenetic development, if if it does

not receive a spermatozoon. It is in the power of the queen-bee to produce male or female individuals: by an act of will she decides whether the egg she is laying is to be fertilized or unfertilized. She "knows beforehand" whether an egg will develop into a male or a female animal, and deposits the latter kind in the cells of queens and workers, the former in the cells of drones. It has been shown by the discoveries of Leuckart and von Siebold that all the eggs are capable of developing into male individuals, and that they are only transformed into "female eggs" by fertilization. This fact seems to be incompatible with my theory as to the cause of parthenogenesis, for if the same egg, possessing exactly the same contents, and above all the same segmentation nucleus, may develop sexually or parthenogenetically, it appears that the power of parthenogenetic development must depend on some factor other than the quantity of germ-plasm.

Although this appears to be the case, I believe that my theory encounters no real difficulty. I have no doubt whatever that the same egg may develop with or without fertilization. From a careful study of the numerous excellent investigations upon this point which have been conducted in a particularly striking manner by Bessels (in addition to the observers quoted above), I have come to the conclusion that the fact is absolutely certain. It must be candidly admitted that the same egg will develop into a drone when not fertilized, or into a worker or queen when fertilized. One of Bessels' experiments is sufficient to prove this assertion. He cut off the wings of a young queen and thus rendered her incapable of taking "the nuptial flight." He then observed that all the eggs which she laid developed into male individuals. This experiment was made in order to prove that drones are produced by unfertilized eggs; but it also proves that the assertion mentioned above is correct, for the eggs which ripen first and are therefore first laid, would have been fertilized had the queen been impregnated. The supposition that, at certain times, the queen produces eggs requiring fertilization, while at other times her eggs develop parthenogenetically, is quite excluded by this experiment; for it follows from it that the eggs must all be of precisely the same kind, and that there is no difference between the eggs which require fertilization and those which do not.

But does it therefore follow that the quantity of germ-plasm in the segmentation nucleus is not the factor which determines the beginning of embryonic development? I believe not. It can be very well imagined that the nucleus of the egg, having expelled the ovogenetic nucleo-

ROBERT I

plasm, may be increased to the size requisite for the segmentation nucleus in one of two ways: either by conjugation with a sperm-nucleus, or by simply growing to double its size. There is nothing improbable in this latter assumption, and one is even inclined to inquire why such growth does not take place in all unfertilized eggs. The true answer to this question must be that nature pursues the sexual method of reproduction, and that the only way in which the general occurrence of parthenogenesis could be prevented was by the production of eggs which remained sterile unless they were fertilized. This was effected by a loss of the capability of growth on the part of the egg-nucleus after it had expelled the ovogenetic nucleoplasm.

The case of the bee proves in a very striking manner that the difference between eggs which require fertilization, and those which do not, is not produced until after the maturation of the egg and the removal of the ovogenetic nucleoplasm. The increase in the quantity of the germ-plasm cannot have taken place at any earlier period, or else the nucleus of the egg would always start embryonic development by itself, and the egg would probably be incapable of fertilization. For the relation between egg-nucleus and sperm-nucleus is obviously based upon the fact that each of them is insufficient by itself, and requires completion. If such completion had taken place at an early stage the egg-nucleus would either cease to exercise any attractive force upon the sperm-nucleus, or else conjugation would be effected, as in Fol's interesting experiments upon fertilization by many spermatozoa; and, as in these experiments, malformation of the embryo would result. In Daphnidae I believe I have shown that the summer eggs are not only developed parthenogenetically, but also that they are never fertilized; and the explanation of this incapacity for fertilization may perhaps be found in the fact that their segmentation nucleus is already formed.

We may therefore conclude that, in bees, the nucleus of the egg, formed during maturation, may either conjugate with the sperm-nucleus, or else if no spermatozoon reaches the egg may, under the stimulus of internal causes, grow to double its size, thus attaining the dimensions of the segmentation nucleus. For our present purpose we may leave out of consideration the fact that in the latter case the individual produced is a male, and in the former case a female.

# ROBERT KOCH

ROBERT KOCH was born at Klausthal, Hanover, Germany, Dec. 11, 1843, and graduated from the University of Göttingen in 1866. He was assistant surgeon to the General Hospital at Hamburg for a time and afterwards practiced medicine at Langenhagen, Kackwitz, and Wollenstein, where he lived from 1872 to 1880. It was here that he began his researches in bacteriology. His investigations on the ætiology of anthrax, published in 1876, and his important study of the ætiology of anthrax published in 1878 placed bacteriology on a scientific basis. In 1880 Dr. Koch went to Berlin to accept a position as chief of the Sanitary Institute of Berlin; here he carried on his studies of the *contagia* of consumption and cholera. Koch claims that each disease is caused by a specific micro-organism. In 1882 he announced his discovery of the tubercle bacillus. In order to reach his conclusions he invented new microscopical appliances, and new methods of staining specimens in order to make those micro-organisms visible, thus making a very important advance in microscopy. In 1883 Dr. Koch published a method of preventive inoculation against anthrax. In the same year the German Government sent him to Egypt and India to investigate cholera, where he discovered the cholera bacillus. On his return to Germany in 1884 he was generously rewarded by the Government. He went to France as cholera commissioner early in 1885 and later was appointed Professor of the Medical Faculty of the University of Berlin, Director of the Prussian Board of Health, and Director of the Hygienic Institute of Berlin. He published a paper on the prophylaxis of infectious diseases in the army in 1888. In 1890 he announced the discovery of the bacillus of consumption.

In 1896 he visited South Africa to study the cattle plague. In 1901 Dr. Koch attended the British Congress on Tuberculosis held in London and presided over by Lord Lister, where he read an address on "The Combating of Tuberculosis in the Light of the Experience Gained in the Successful Combating of Other Infectious Diseases." He produced what was held by the Congress to be satisfactory evidence that

human tuberculosis was not transmissible to animals; but there was some hesitation in accepting his conclusion that bovine tuberculosis could not be transmitted to the human subject by infected meat, milk, etc.

## THEORY OF BACTERIA

I am well aware that the investigations above described are very imperfect. It was necessary, in order to have time for those parts of the investigation which seemed the most important and essential, to omit the examination of many organs, such as the brain, heart, retina, etc., which ought not to pass unnoticed in researches on infective diseases. For the same reason no record was kept of the temperature, although this would undoubtedly have yielded most interesting results. I have intentionally refrained from entering into details of morbid anatomy, as only the etiology interested me, and as I did not feel qualified to undertake a study of the morbid anatomy of traumatic infective diseases. I must therefore leave this part of the investigation to those who are better able to undertake it.

Nevertheless I consider that the results of my researches are sufficiently definite to enable me to deduce from them some well founded conclusions.

In this summary I shall, however, confine myself to the most obvious conclusions. It has indeed of late become too common to draw the most sweeping conclusions as to infective diseases in general from the most unimportant observations on bacteria. I shall not follow this custom, although the material at my command would furnish rich food for meditation. For the longer I study infective diseases the more am I convinced that generalisations of new facts are here a mistake, and that every individual infective disease or group of closely allied diseases must be investigated for itself.

As regards the artificial traumatic infective diseases observed by me, the conditions which must be established before their parasitic nature can be proved, we completely fulfilled in the case of the first five, but only partially in that of the sixth. For the infection was produced by such small quantities of fluid (blood, serum, pus, etc.,) that the result cannot be attributed to a merely chemical poison.

In the materials used for inoculation bacteria were without exception present, and in each disease a different and well marked form of organism could be demonstrated.

At the same time, the bodies of those animals which died of the artificial traumatic infective diseases contained bacteria in such numbers that the symptoms and the death of the animals were sufficiently explained. Further, the bacteria found were identical with those which were present in the fluid used for inoculation, and a definite form of organisms corresponded in every instance to a distinct disease.

These artificial traumatic infective diseases bear the greatest resemblance to human traumatic infective diseases, both as regards their origin from putrid substances, their course, and the result of postmortem examination. Further, in the first case, just as in the last, the parasitic organisms could be only imperfectly demonstrated by the earlier methods of investigation; not till an improved method of procedure was introduced was it possible to obtain complete proof that they were parasitic diseases. We are therefore justified in assuming that human traumatic infective diseases will in all probability be proved to be parasitic when investigated by these improved methods.

On the other hand, it follows from the fact that a definite pathogenic bacterium, e. g., the septicæmic bacillus, cannot be inoculated on every variety of animal (a similar fact is also true with regard to the bacillus anthracis); that the septicæmia of mice, rabbits, and man are not under all circumstances produced by the same bacterial form. It is of course possible that one or other of the bacteric forms found in animals also play a part in such diseases in the human subject. That, however, must be especially demonstrated for each case; *a priori* one need only expect that bacteria are present; as regards form, size and conditions of growth, they may be similar, but not always the same, even in what appear to be similar diseases in different animals.

Besides the pathogenic bacteria already found in animals there are no doubt many others. My experiments refer only to those diseases which ended fatally. Even these are in all probability not exhausted in the six forms mentioned. Further experiments on many different species of animals, with the most putrid substances and with every possible modification in the method of application, will doubtless bring to light a number of other infective diseases, which will lead to further conclusions regarding infective diseases and pathogenic bacteria.

But even in the small series of experiments which I was able to carry out, one fact was so prominent that I must regard it as constant, and, as it helps to remove most of the obstacles to the admission of the existence of a centagium vivum for traumatic infective diseases, I look

on it as the most important result of my work. I refer to the differences which exist between pathogenic bacteria and to the constancy of their characters. A distinct bacteric form corresponds, as we have seen, to each disease, and this form always remains the same, however often the disease is transmitted from one animal to another. Further, when we succeed in reproducing the same disease *de novo* by the injection of putrid substances, only the same bacteric form occurs which was before found to be specific for that disease.

Further, the differences between these bacteria are as great as could be expected between particles which border on the invisible. With regard to these differences, I refer not only to the size and form of the bacteria, but also to the conditions of their growth, which can be best recognized by observing their situation and grouping. I therefore study not only the individual alone, but the whole group of bacteria, and would, for example, consider a micrococcus which in one species of animal occurred only in masses (i. e., in a zooglæa form), as different from another which in the same variety of animal, under the same conditions of life, was only met with as isolated individuals. Attention must also be paid to the physiological effect, of which I scarcely know a more striking example than the case of the bacillus and the chain-like micrococcus growing together in the cellular tissue of the ear; the one passing into the blood and penetrating into the white blood corpuscles, the other spreading out slowly into the tissues in its vicinity and destroying everything around about; or again, the case of the septicæmic and pyæmic micrococci of the rabbit in their different relations to the blood; or lastly, the bacilli only extending over the surface of the aural cartilage in the erysipetalous disease, as contrasted with the bacillus anthracis, likewise inoculated on the rabbit's ear, but quickly passing into the blood.

As, however, there corresponds to each of the diseases investigated a form of bacterium distinctly characterized by its physiological action, by its conditions of growth, size, and form, which, however often the disease be transmitted from one animal to another, always remains the same and never passes over into another form, e. g., from the spherical to the rod shaped, we must in the meantime regard these different forms of pathogenic bacteria as distinct and constant species.

This is, however, an assertion that will be much disputed by botanists, to whose special province this subject really belongs.

Amongst those botanists who have written against the subdivision

of bacteria into species, is Nägeli, who says, "I have for ten years examined thousands of different forms of bacteria, and I have not yet seen any absolute necessity for dividing them even into two distinct species."

Brefeld also states that he can only admit the existence of specific forms justifying the formation of distinct species when the whole history of development has been traced by cultivation from spore to spore in the most nutritive fluids.

Although Brefeld's demand is undoubtedly theoretically correct, it cannot be made a *sine qua non* in every investigation on pathogenic bacteria. We should otherwise be compelled to cease our investigations into the etiology of infective diseases till botanists have succeeded in finding out the different species of bacteria by cultivation and development from spore to spore. It might then very easily happen that the endless trouble of pure cultivation would be expended on some form of bacterium which would finally turn out to be scarcely worthy of attention. In practice only the opposite method can work. In the first place certain peculiarities of a particular form of bacterium different from those of other forms, and in the second place its constancy, compel us to separate it from others less known and less interesting, and provisionally to regard it as a species. And now, to verify this provisional supposition, the cultivation from spore to spore may be undertaken. If this succeeds under conditions which cut out all sources of fallacy, and of it furnishes a result corresponding to that obtained by the previous observations, then the conclusions which were drawn from these observations and which led to its being ranked as a distinct species must be regarded as valid.

On this, which as it seems to me is the only correct practical method, I take my stand, and, till the cultivation of bacteria from spore to spore shows that I am wrong, I shall look on pathogenic bacteria as consisting of different species.

In order, however, to show that I do not stand alone in this view, I shall here mention the opinion of some botanists who have already come to a similar conclusion.

Cohn states that, in spite of the fact that many dispute the necessity of separating bacteria into genera or species, he must nevertheless adhere to the method as yet followed by him, and separate bacteria of a different form and fermenting power from each other, so long as complete proof of their identity is not given.

From his investigations on the effects of different temperatures and

of desiccation on the development of bacterium termo, Eidam came to the conclusion that different forms of bacteria require different conditions of nutriment, and that they behave differently towards physical and chemical influences. He regards these facts as a further proof of the necessity of dividing organisms into distinct species.

I shall bring forward another reason to show the necessity of looking on the pathogenic bacteria which I have described as distinct species. The greatest stress, in investigations on bacteria, is justly laid on the so-called pure cultivations, in which only one definite form of bacterium is present. This evidently arises from the view that if, in a series of cultivations, the same form of bacterium is always obtained, a special significance must attach to this form: it must indeed be accepted as a constant form, or in a word as a species. Can, then, a series of pure cultivations be carried out without admixture of other bacteria? It can in truth be done, but only under very limited conditions. Only such bacteria can be cultivated pure, with the aids at present at command, which can always be known to be pure, either by their size and easily recognizable form, as the bacillus anthracis, or by the production of a characteristic coloring matter as the pigment bacteria. When, during a series of cultivations, a strange species of bacteria has by chance got in, as may occasionally happen under any circumstances, it will in these cases be at once observed, and the unsuccessful experiment will be thrown out of the series without the progress of the investigation being thereby necessarily interfered with.

But the case is quite different when attempts are made to carry out cultivations of very small bacteria, which, perhaps, cannot be distinguished at all without staining; how are we then to discover the occurrence of contamination? It is impossible to do so, and therefore all attempts at pure cultivation in apparatus, however skillfully planned and executed, must, as soon as small bacteria with but little characteristic appearances are dealt with, be considered as subject to unavoidable sources of fallacy, and in themselves inconclusive.

But nevertheless a pure cultivation is possible, even in the case of the bacteria which are smallest and most difficult to recognise. This, however, is not conducted in cultivation apparatus, but in the animal body. My experiments demonstrate this. In all the cases of a distinct disease, e. g., of septicæmia of mice, only the small bacilli were present, and no other form of bacterium was ever found with it, unless in the case where that causing the tissue gangrene was intentionally inoculated

at the same time. In fact, there exists no better cultivation apparatus for pathogenic bacteria than the animal body itself. Only a very limited number of bacteria can grow in the body, and the penetration of organisms into it is so difficult that the uninjured living body may be regarded as completely isolated with respect to other forms of bacteria than those intentionally introduced. It is quite evident, from a careful consideration of the two diseases produced in mice-septicæmia and gangrene of the tissue—that I have succeeded in my experiments in obtaining a pure cultivation. In the putrefying blood, which was the cause of these two diseases, the most different forms of bacteria were present, and yet only two of these found in the living mouse the conditions necessary for their existence. All the others died, and these two alone, a small bacillus and a chain-like micrococcus, remained and grew. These could be transferred from one animal to another as often as was desired, without suffering any alteration in their characteristic form, in their specific physiological action and without any other variety of bacteria at any time appearing. And further, as I have demonstrated, it is quite in the power of the experimenter to separate these two forms of bacteria from each other. When the blood in which only the bacilli are present is used, these alone are transmitted, and thenceforth are obtained quite pure; while on the other hand, when a field mouse is inoculated with both forms of bacteria, the bacilli disappear, and the micrococcus can be then cultivated pure. Doubtless an attempt to unite these two forms again in the same animal by inoculation would have been successful. In short, one has it completely in one's power to cultivate several varieties of bacteria together, to separate them from each other, and eventually to combine them again. Greater demands can hardly be made on a pure cultivation, and I must therefore regard the successive transmission of artificial infective diseases as the best and surest method of pure cultivation. And it can further claim the same power of demonstrating the existence of specific forms of bacteria, as must be conceded to any faultless cultivation experiments.

From the fact that the animal body is such an excellent apparatus for pure cultivation, and that, as we have seen, when the experiments are properly arranged and sufficient optical aids used, only one specific form of bacterium can be found in each distinct case of artificial traumatic infective disease, we may now further conclude that when, in examining a traumatic infective disease, several different varieties of bacteria are found, as e. g., chains of small granules, rods, and long, oscil-

lating threads—such as were seen together by Coze and Feltz in the artificial septicæmia of rabbits—we have to do either with a combined infective disease,—that is, not a pure one,—or, what in the case cited is more probable, an inexact and inaccurate observation. When, therefore, several species of bacteria occur together in any morbid process, before definite conclusions are drawn as to the relations of the disease in question to the organisms, either proof must be furnished that they are all concerned in the morbid process, or an attempt must be made to isolate them and to obtain a true pure cultivation. Otherwise we cannot avoid the objection that the cultivation was not pure, and therefore not conclusive. I shall only briefly refer to a further necessary consequence of the admission of the existence of different species of pathogenic bacteria. The number of the species of these bacteria is limited; for, of the numerous diverse forms present in putrid fluids, one or but few can in the most favorable cases develop in the animal body. Those which disappear are, for that species of animal at least, not pathogenic bacteria. If, however, as follows from the foregoing, there exist hurtful and harmless bacteria, experiments performed on animals with the latter, e. g., with bacterium termo, prove absolutely nothing for or against the behavior of the former—the pathogenic—forms. But almost all the experiments of this nature have been carried out with the first mixture of different species of bacteria which came to hand without there being any certainty that pathogenic bacteria were in reality present in the mixture. It is therefore evident that none of these experiments can be regarded as furnishing evidence of any value for or against the parasitic nature of infective diseases.

In all my experiments, not only have the form and size of the bacteria been constant, but the greatest uniformity in their actions on the animal organisms has been observed, though no increase of virulence, as described by Coze and Feltz, Davaine, and others. This leads me to make some remarks on the supposed law of the increasing virulence of blood when transmitted through successive animals, discovered or confirmed by the investigators just named.

The discovery of this law has as is well known, been received with great enthusiasm, and it has excited no little interest owing to its intimate bearing on the doctrine of natural selection (Anpassung and Vererbung). Some investigators, who are in other things very exact, have allowed themselves to be blinded by the seductive theory that the insignificant action of a single putrefactive bacterium may, by continued

natural selection in passing from animal to animal, be increased in virulence till it becomes deadly though a drop of the infective liquid be diluted in a quadrillion times. They have founded thereon the most beautiful practical applications, not suspecting that the bacteria in question have never been certainly demonstrated.

The original works of Coze and Feltz, as also that of Davaine, are not at my disposal for reference; and I cannot therefore enter into a complete criticism of them. So far, however, as I can gather from the references accessible to me, especially from the detailed notices in Virchow and Hirch's "Jahnesbericht," no complete proof that the virulence of septicæmic blood increases from generation to generation seems to have been furnished. Apparently blood more and more diluted was injected, and astonishment was felt when this always acted, the effect being then ascribed to its increasing virulence. But controlling experiments to ascertain whether the septicæmic blood were not already as virulent in the second and third generations as in the twenty-fifth, do not seem to have been made. My experiments so far support and are in accordance with those of Coze, Feltz, and Davaine in that for the first infection of an animal relatively large quantities of putrid fluid are necessary; but in the second generation, or at the latest in the third, the full virulence was attained, and afterwards remained constant.

Of my artificial infective diseases the septicæmia of the mouse has the greatest correspondence with the artificial septicæmia described by Davaine. If we were to experiment with this disease in the same manner as Davaine experimented, we would, if no controlling experiments were employed, find the same increase in virulence of the disease. It would only be necessary to use blood in slowly decreasing quantities in order to obtain in this way any progressive increase of the virulence that might be desired. I, however, took from the second or third animal the smallest possible quantity of material for inoculation, and thus arrived more quickly at the greatest degree of virulence. Till, therefore, I am assured that, in the septicæmia observed by Davaine, such controlling experiments were made, I can only look on an increase in virulence as holding good for the earlier generations. In order to explain this we do not, however, require to have recourse to the magical wand of natural selection; a feasible explanation can be very naturally furnished. Let us take again the septicæmia of mice, as being the most suitable example.

If two drops of putrefying blood be injected into such an animal

there is introduced not only a number of totally distinct species of bacteria, but also a certain amount of dissolved putrid poison (sepsin), not sufficient to produce a fatal effect, but yet certainly not without influence on the health of the animal. Different factors must therefore be considered as affecting the health of the animal. On the one hand there is the dissolved poison, on the other the different species of bacteria, of which, however, perhaps only two, as in the example before us, can multiply in the body of the mouse and there exert a continuous noxious influence. Only one of these two species can penetrate into the blood, and if the blood alone be used for further inoculations, only this one variety will come victorious out of the battle for existence. The further development of the experiment depends entirely on the quantity of the putrid poison, and on the relation of the two forms of bacteria to each other in point of numbers. If one injects a large amount of septic poison and a large number of that variety of bacteria which increases locally (in this case the chain-like micrococci causing the gangrene of the tissue), but only a very small number of the bacteria which pass into the blood (here the bacilli), the first animal experimented on will die, as a result of the preponderation influence of the first two factors before many bacilli can have got into the blood and multiplied there. Of the blood of this first animal, containing, as it does, proportionately very few bacilli, one-fifth to one-tenth of a drop must be inoculated in order to convey the disease with certainty. In the second animal, however, only the bacilli are introduced, and these develop undisturbed in the blood. For the infection of the third animal the smallest quantity of this blood which can produce an effect is then sufficient, and after this third generation the virulence of the blood remains uniform.

We may also imagine another case in which the increase of the virulence may go on through more than two generations without any modification resulting from natural selection and transmission from animal to animal. This would take place if several species of bacteria capable of passing into the blood were introduced into the animal at the first injection. Let us suppose, for example, that in the same putrefying blood which served for the foregoing experiment, the bacilli of anthrax were also present, there would then be contained in the blood of the first animal not only the septicæmic bacillus, but also bacillus anthracis, and of each only a small number; of the anthrax bacillus there would be even fewer than of the other, because in mice they are deposited chiefly in the spleen, lungs, etc.; while in the blood of the heart they

are, even in the most favorable cases, only sparsely distributed. On the other hand, the anthrax bacilli have this advantage, that, provided they be inoculated in considerable numbers, they kill even within twenty hours, while the septicæmic bacilli only destroy life after fifty hours. In the blood of the second animal, therefore, both species of bacilli would be present in larger numbers than in the first, although not yet so numerous as if either organism had been inoculated singly. Hence a larger quantity of blood is necessary to ensure transmission to a third animal. Perhaps this might be the case even in the fourth generation, till finally one or other variety of bacillus would alone be present in the blood injected. Probably this would be the septicæmic bacillus.

In this way the experiments of Coze, Feltz, and Davaine may admit of simple explanation and be brought into harmony with my results.

## LOUIS PASTEUR

Louis Pasteur was born at Dôle, France, December 27, 1822. His father was a tanner. In 1825 the family moved to Arbois, where Pasteur was sent to college. Later he attended Besançon, where he took his bachelor's degree. He now went to the Ecole Normale to continue his studies in chemistry, and three years later he was appointed assistant professor there. His first important scientific work was done in showing the asymmetry of molecules, but this is not the field in which he made his greatest reputation. In 1863 he took up the question of fermentation and showed that it is due to the growth of bacteria—microscopic plants—and soon afterward proved the same fact to be the cause of putrefaction. This immediately led to Lister's conception of antiseptic surgery and dealt a fatal blow to the doctrine of spontaneous generation.

In 1865 Pasteur discovered the bacillus which was the cause of the silkworm disease.

Davaine had discovered the bacillus of anthrax in 1863, and Pasteur took up the question of inoculation on the theoretical principle of small-pox vaccination. After passing the germs successively through a number of animals, he found that a few drops of blood from an infected

# PASTEUR

animal constituted a lymph which, if injected gradually and in small enough quantities, would cause only a mild attack of anthrax, which would act as a preventive thereafter. This is the great principle of inoculation with which scientists are to-day attempting to combat the infectious diseases. Pasteur himself applied it with great success to the cure of hydrophobia in 1880-1885. He found that the inoculation acted as an almost certain preventive even after patients were bitten by a mad dog.

He died September 28, 1895.

The extracts first given below will give some idea of his work on fermentation. His account of his work on hydrophobia follows later.

## ON FERMENTATION

We maintain, adducing incontestable experimental evidence in support of our theory, that living, organized ferments spring only from similar organisms likewise endowed with life; and that the germs of these ferments exist in a state of suspension in the air, or on the exterior surface of objects. M. Fremy asserts that these ferments are formed by the force of hemi-organisms acting on albuminous substances, in contact with the air. We may put the matter more precisely by two examples:—

Wine is produced by a ferment, that is to say, by minute, vegetative cells which multiply by budding. According to us, the germs of these cells abound in autumn on the surface of grapes and on the woody parts of their branches; and the proofs which we have given of this fact are as clear as any evidence can be. According to M. Fremy, the cells of ferment are produced by spontaneous generation, that is to say, by the transformation of nitrogenous substances contained in the juice of the grape, as soon as that juice is brought into contact with the air.

Again, blood flows from a vein; it putrefies, and in a very short time swarms with bacteria or virbios. According to us the germs of these bacteria and virbios have been introduced by particles of dust floating in the air or derived from the surface of objects, possibly the body of the wounded animal, or the vessels employed, or a variety of other objects. M. Fremy, on the other hand, asserts that these bacteria or virbios are produced spontaneously, because the albumin, and the fibrin of the blood themselves possess a semi-organization, which causes

them, when in contact with the air, to change spontaneously into these marvelously active minute beings.

Has M. Fremy given any proof of the truth of his theory? By no manner of means; he confines himself to asserting that things are as he says they are. He is constantly speaking of hemi-organism and its effects, but we do not find his affirmations supported by a single experimental proof. There is, nevertheless, a very simple means of testing the truth of the theory of hemi-organism; and on this point M. Fremy and ourselves are quite at one. This means consists in taking a quantity of grape juice, wine, blood, etc., from the very interior of the organs which contain those liquids, with the necessary precautions to avoid contact with the particles of dust in suspension in the air or spread over objects. According to the hypothesis of M. Fremy, these liquids must of necessity ferment in the presence of pure air. According to us, the very opposite of this must be the case. Here, then, is a crucial experiment of the most decisive kind for determining the merits of the rival theories, a criterion, moreover, which M. Fremy perfectly admits. In 1863, and again in 1872, we published the earliest experiments that were made in accordance with this decisive method. The result was as follows: The grape juice did not ferment in vessels full of air, air deprived of its particles of dust—that is to say, it did not produce any of the ferments of wine; the blood did not putrefy—that is to say, it yielded neither bacteria nor virbios; urine did not become ammoniacal—that is to say, it did not give rise to any organism; in a word, the origin of life manifested itself in no single instance.

The hemi-organism hypothesis is, therefore, absolutely untenable, and we have no doubt that our learned friend will eventually declare as much before the Academy, since he has more than once publicly expressed his readiness to do so as soon as our demonstrations appear convincing to him. How can he resist the evidence of such facts and proofs? Persistence in such a course can benefit nobody, but it may depreciate the dignity of science in general esteem. It would gratify us extremely to find the rigorous exactness of our studies on this subject acknowledged by M. Fremy, and regarded by that gentleman with the same favour bestowed upon it everywhere abroad. It may be doubted if there exists at the present day a single person beyond the Rhine who believes in the correctness of Liebig's theory, of which M. Fremy's hemi-organism is merely a variation. If M. Fremy still hesitates to accept our demonstrations, the observations of Mr. Tyndall may effect his conversion.

London, February 16, 1876.

"Dear Mr. Pasteur:

"For the first time in the history of science, we are justified in cherishing confidently the hope that, as far as epidemic diseases are concerned, medicine will soon be delivered from empiricism, and placed on a real scientific basis; when that great day shall come, humanity will, in my opinion, recognize the fact that the greatest part of its gratitude will be due to you.

"Believe me, ever very faithfully yours,

"JOHN TYNDALL."

We need scarcely say that we read this letter with liveliest gratification, and were delighted to learn that our studies had received the support of one renowned in the scientific world alike for rigorous accuracy in his experiments as for the lucid and picturesque clearness of all his writings. The reward as well as the ambition of the man of science consists in earning the approbation of his fellow-workers, or that of those he esteems masters.

Mr. Tyndall has observed this remarkable fact, that in a box, the sides of which are coated with glycerine, and the dimensions of which may be variable and of considerable size, all the particles of dust floating in the air inside fall and adhere to the glycerine in the course of a few days. The air in the case is then as pure as that in our double-necked flasks. Moreover, a transmitted ray of light will tell us the moment when this purity is obtained. Mr. Tyndall has proved, in fact, that to the eye rendered sensitive by remaining in darkness for a little while, the course of the ray is visible as long as there are any floating particles of dust capable of reflecting or diffusing light, and that, on the other hand, it becomes quite obscure and invisible to the same eye as soon as the air has deposited all its solid particles. When it has done this, which it will do very quickly—in two or three days, if we employ one of the boxes used by Mr. Tyndall—it has been proved that any organic infusions whatever may be preserved in the case without undergoing the least putrefactive change, or without producing bacteria.

On the other hand, bacteria will swarm in similar infusions, after an interval of from two to four days, if the vessels which contain them are exposed to the air by which the cases are surrounded. Mr. Tyndall can drop into his boxes, at any time he wishes, some blood from a vein or an artery of an animal, and show conclusively that such blood will not, under these circumstances, undergo any putrefactive change.

Mr. Tyndall concludes his work with a consideration of the probable application of the results given in his paper to the etiology of contagious diseases. We share his views on this subject entirely, and we

are obliged to him for having recalled to mind the following statement from our *Studies on the Silkworm Disease:* "Man has it in his power to cause parasitic diseases to disappear off the surface of the globe, if, as we firmly believe, the doctrine of spontaneous generation is a chimera."

## INOCULATION FOR HYDROPHOBIA

Gentlemen:—Your Congress meetings are the place for the discussion of the gravest problems of medicine; they serve also to point out the great landmarks of the future. Three years ago, on the eve of the London Congress, the doctrine of micro-organisms, the ætiological cause of transmissible maladies, was still the subject of sharp criticisms. Certain refractory minds continued to uphold the idea that "disease is in us, from us, by us."

It was expected that the decided supporters of the theory of the spontaneity of diseases would make a bold stand in London; but no opposition was made to the doctrine of "exteriority," or external causes, the first cause of contagious diseases, and those questions were not discussed at all.

It was there seen, once again, that when all is ready for the final triumph of truth, the united conscience of a great assembly feels it instinctively and recognises it.

All clear-sighted minds had already foreseen that the theory of the spontaneity of diseases received its death-blow on the day when it became possible reasonably to consider the spontaneous generation of microscopic organisms as a myth, and when, on the other hand, the life-activity of those same beings was shown to be the main cause of organic decomposition and of all fermentation.

From the London Congress, also, dates the recognition of another very hopeful progress; we refer to the attenuation of different viruses, to the production of varying degrees of virulence for each virus, and their preservation by suitable methods of cultivation; to the practical application, finally, of those new facts in animal medicine.

New microbic prophylactic viruses have been added to those of fowl-cholera and of splenic fever. The animals saved from death by contagious diseases are now counted by hundreds of thousands, and the sharp opposition which those scientific novelties met with at the

beginning was soon swept away by the rapidity of their onward progress.

Will the circle of practical applications of those new notions be limited in future to the prophylaxis of animal distempers? We must never think little of a new discovery, nor despair of its fecundity; but more than that, in the present instance, it may be asserted that the question is already solved in principle. Thus, splenic fever is common to animals and man, and we make bold to declare that, were it necessary to do so, nothing could be easier than to render man also proof against that affection. The process which is employed for animals might, almost without a change, be applied to him also. It would simply become advisable to act with an amount of prudence which the value of the life of an ox or a sheep does not call for. Thus, we should use three or four vaccine-viruses instead of two, of progressive intensity of virulence, and choose the first ones so weak that the patient should never be exposed to the slightest morbid complication, however susceptible to the disease he might be by his constitution.

The difficulty, then, in the case of human diseases, does not lie in the application of the new method of prophylaxis, but rather in the knowledge of the physiological properties of their viruses. All our experiments must tend to discover the proper degree of attenuation for each virus. But experimentation, if allowable on animals, is criminal on man. Such is the principal cause of the complication of researches bearing on diseases exclusively human. Let us keep in mind, nevertheless, that the studies of which we are speaking were born yesterday only, that they have already yielded valuable results, and that new ones may be fairly expected when we shall have gone deeper into the knowledge of animal maladies, and of those in particular which affect animals in common with man.

The desire to penetrate farther forward in that double study led me to choose rabies as the subject of my researches, in spite of the darkness in which it was veiled.

The study of rabies was begun in my laboratory four years ago, and pursued since then without other interruption than what was inherent to the nature of the researches themselves, which present certain unfavourable conditions. The incubation of the disease is always protracted, the space disposed of is never sufficient, and it thus becomes impossible at a given moment to multiply the experiments as one would like. Notwithstanding those material obstacles, lessened by the interest

taken by the French Government in all questions of great scientific interest, we now no longer count the experiments which we have made, my fellow workers and myself. I shall limit myself to-day to an exposition of our latest acquisitions.

The name alone of a disease, and of rabies above all others, at once suggests to the mind the notion of a remedy.

But it will, in the majority of cases, be labour lost to aim in the first instance at discovering a mode of cure. It is, in a manner, leaving all progress to chance. Far better to endeavour to acquaint oneself, first of all, with the nature, the cause, and the evolution of the disease, with a glimmering hope, perhaps, of finally arriving at its prophylaxis.

To this last method we are indebted for the result that rabies is no longer to-day to be considered as an insoluble riddle.

We have found that the virus of rabies develops itself invariably in the nervous system, brain, and spinal cord, in the nerves, and in the salivary glands; but it is not present at the same moment in every one of those parts. It may, for example, develop itself at the lower extremity of the spinal cord, and only after a time reach the brain. It may be met with at one or at several points of the encephalon whilst being absent at certain other points of the same region.

If an animal is killed whilst in the power of rabies, it may require a pretty long search to discover the presence here or there in the nervous system, or in the glands, of the virus of rabies. We have been fortunate enough to ascertain that in all cases, when death has been allowed to supervene naturally, the swelled-out portion, or bulb, of the medulla oblongata nearest to the brain, and uniting the spinal cord with it, is always rabid. When an animal has died of rabies (and the disease always ends in death), rabid matter can with certainty be obained from its bulb, capable of reproducing the disease in other animals when inoculated into them, after trephining, in the arachnoid space of the cerebral meninges.

Any street dog whatsoever, inoculated in the manner described with portions of the bulb of an animal which has died of rabies, will certainly develop the same disease. We have thus inoculated several hundreds of dogs brought without any choice from the pound. Never once was the inoculation a failure. Similarly also, with uniform success, several hundred guinea-pigs, and rabbits more numerous still.

Those two great results, the constant presence of the virus in the bulb at the time of death, and the certainty of the reproduction of the

disease by inoculaion into the arachnoid space, stand out like experimental axioms, and their importance is paramount. Thanks to the precision of their application, and to the well-nigh daily repetition of those two criteria of our experiments, we have been able to move forward steadily and surely in that arduous study. But, however solid those experimental bases, they were, nevertheless, incapable in themselves of giving us the faintest notion as to some method of vaccination against rabies. In the present state of science the discovery of a method of vaccination against some virulent malady presupposes:

1. That we have to deal with a virus capable of assuming diverse intensities, of which the weaker ones can be put to vaccinal or protective uses.

2. That we are in possession of a method enabling us to reproduce those diverse degrees of virulence at will.

At the present time, however, science is acquainted with one sort of rabies only—viz., dog rabies.

Rabies, whether in dog, man, horse, ox, wolf, fox, etc., comes originally from the bite of a mad dog. It is never spontaneous, neither in the dog nor in any other animal. There are none seriously authenticated among the alleged cases of so-called spontaneous rabies, and I add that it is idle to argue that the first case of rabies of all must have been spontaneous. Such an argument does not solve the difficulty, and wantonly calls into question the as yet inscrutable problem of the origin of life. It would be quite as well, against the assertion that an oak tree always proceeded from another oak tree, to argue that the first of all oak trees that ever grew must have been produced spontaneously. Science, which knows itself, is well aware that it would be useless for her to discuss about the origin of things; she is aware that, for the present at any rate, that origin is placed beyond the ken of her investigations.

In fine, then, the first question to be solved on our way towards the prophylaxis of rabies is that of knowing whether the virus of that malady is susceptible of taking on varying intensities, after the manner of the virus of fowl-cholera or of splenic fever.

But in what way shall we ascertain the possible existence of varying intensities in the virus of rabies? By what standard shall we measure the strength of a virus which either fails completely or kills? Shall we have recourse to the visible symptoms of rabies? But those symptoms are extremely variable, and depend essentially on the particular point of the encephalon or of the spinal cord where the virus has in the

first instance fixed and developed itself. The most caressing rabies, for such do exist, may, when inoculated into another animal of the same species, give rise to furious rabies of the intensest type.

Might we then perhaps make use of the duration of incubation as a means of estimating the intensity of our virus? But what can be more changeful than the incubative period? Suppose a mad dog to bite several sound dogs: one of them will take rabies in one month or six weeks, another after two or three months or more. Nothing, too, more changeful than the length of incubation according to the different modes of inoculation. Thus, other circumstances the same, after bites or hypodermic inoculation rabies occasionally develops itself, and at other times aborts completely; but inoculations on the brain are never sterile, and give the disease after a relatively short incubation.

It is possible, nevertheless, to gauge with sufficient accuracy the degree of intensity of our virus by means of the time of incubation, on condition that we make use exclusively of the intra-cranial mode of inoculation; and secondly, that we do away with one of the great disturbing influences inherent to the results of inoculation made by bites, under the skin or in the veins, by injecting the right proportion of material.

The duration of incubation, as a matter of fact, may depend largely on the quantity of efficient virus—that is to say, on the quantity of virus which reaches the nervous system without diminution or modification. Although the quantity of virus capable of giving rabies may be, so to speak, infinitely small, as seen in the common fact of the disease developing itself after rabid bites which, as a rule, introduce into the system a barely appreciable weight of virus, it is easy to double the length of incubation by simply changing the proportion of those very small quantities of inoculated matter. I may quote the following examples:—

On May 10, 1882, we injected into the popliteal vein of a dog ten drops of a liquid prepared by crushing a portion of the bulb of a dog, which had died of ordinary canine madness, in three or four times its volume of sterilised broth.

Into a second dog we injected $\frac{1}{10}$th of that quantity, into a third $\frac{1}{100}$th. Rabies showed itself in the first dog on the eighteenth day after the injection, on the thirty-fifth day in the second dog, whilst the third one did not take the disease at all, which means that, for the last animal, with the particular mode of inoculation employed, the quantity of virus injected was not sufficient to give rabies. And yet that

dog, like all dogs, was susceptible of taking the disease, for it actually took it twenty-two days after a second inoculation, performed on September 3, 1882.

I now take another example bearing on rabbits, and by a different mode of inoculation. This time, after trephining, the bulb of a rabbit which had died of rabies after inoculation of an extremely powerful virus is triturated and mixed with two or three times its volume of sterilised broth. The mixture is allowed to stand a little, and then two drops of the supernatant liquid are injected after trephining into a first rabbit, into a second rabbit one-fourth of that quantity, and in succession into other rabbits, $\frac{1}{16}$th, $\frac{1}{64}$th, $\frac{1}{128}$th, and $\frac{1}{162}$nd of that same quantity. All those rabbits died of rabies, the incubation having been eight days, nine and ten days for the third and fourth, twelve and sixteen days for the last ones.

Those variations in the length of incubation were not the result of any weakening or diminution of the intrinsic virulence of the virus brought on possibly by its dilution, for the incubation of eight days was at once recovered when the nervous matter of all those rabbits was inoculated into new animals.

Those examples show that, whenever rabies follows upon bites or hypodermic inoculations, the differences in respect of length of incubation must be chiefly ascribed to the variations, at times within considerable limits, of the ever-undeterminate proportions of the inoculated viruses which reach the central nervous system.

If, therefore, we desire to make use of the length of incubation as a measure of the intensity of the virulence, it will be indispensable to have recourse to inoculation on the surface of the brain, after trephining, a process the action of which is absolutely certain, coupled with the use of a larger quantity of virus than what is strictly sufficient to give rise to rabies. By those means the irregularities in the length of incubation for the same virus tend to disappear completely, because we always have the maximum effect which that virus can produce; that maximum coincides with a minimum length of incubation.

We have thus, finally, become possessed of a method enabling us to investigate the possible existence of different degrees of virulence, and to compare them with one another. The whole secret of the method, I repeat, consists in inoculating on the brain, after trephining, a quantity of virus which, although small in itself, is still greater than what is simply necessary to reproduce rabies. We thus disengage the incu-

bation from all disturbing influences and render its duration dependent exclusively on the activity of the particular virus used, that activity being in each case estimated by the minimum incubation determined by it.

This method was applied in the first instance to the study of canine madness, and in particular to the question of knowing whether dog-madness was always one and the same, with perhaps the slight variations which might be due to the differences of race in diverse dogs.

We accordingly got hold of a number of dogs affected with ordinary street rabies, at all times of the year, at all seasons of the same year or of different years, and belonging to the most dissimilar canine races. In each case the bulbar portion of the medulla oblongata was taken out from the recently dead animal, triturated and suspended in two or three times its volume of sterilised liquid, making use all along of every precaution to keep our materials pure, and two drops of this liquid injected after trephining into one or two rabbits. The inoculation is made with a Pravaz syringe, the needle of which, slightly curved at its extremity, is inserted through the dura-mater into the arachnoid space. The results were as follows: all the rabbits, from whatever sort of dog inoculated, showed a period of incubation which ranged between twelve and fifteen days, without almost a single exception. Never did they show an incubation of eleven, ten, nine, or eight days, never an incubation of several weeks or of several months.

Dog-rabies, the ordinary rabies, the only known rabies, is thus sensibly one in its virulence, and its modifications, which are very limited, appear to depend solely on the varying aptitude for rabies of the different known races. But we are going now to witness a deep change in the virulence of dog-rabies.

Let us take one, any one, of our numerous rabbits, inoculated with the virus of an ordinary mad dog, and, after it has died, extract its bulb, prepare it just as described, and inject two drops of the bulb-emulsion into the arachnoid space of a second rabbit, whose bulb will in turn and in time be injected into a third rabbit, the bulb of which again will serve for a fourth rabbit, and so on.

There will be evidence, even from the first few passages, of a marked tendency towards a lessening of the period of incubation in the succeeding rabbits. Just one example:

Towards the end of the year 1882 fifteen cows and one bull died of rabies on a farm situated in the neighbourhood of the town of Melun.

They had been bitten on October 2 by the farm dog, which had become mad. The head of one of the cows, which had died on November 15, was sent to my laboratory by M. Rossignol, a veterinary surgeon in Melun. A number of experiments were made on dogs and rabbits, and showed that the following parts, the only encephalic (or those pertaining to the brain) ones tested, were rabid: the bulb, the cerebellum, the frontal lobe, the sphenoidal lobe. The rabbits trephined and inoculated with those different parts showed the first symptoms of rabies on the seventeenth and eighteenth days after inoculation. With the bulb of one of those rabbits two more were inoculated, of which one took rabies on the fifteenth day, the other on the twenty-third day.

We may notice, once for all, that when rabies is transferred from one animal to another of a different species, the period of incubation is always very irregular at first in the individuals of the second species if the virus had not yet become fixed in its maximum virulence for the first species. We have just seen an example of that phenomenon, since one of the rabbits had an incubation of fifteen days, the other of twenty-three days, both having received the same virus and all other circumstances remaining apparently the same for them.

The bulb of the first one of those last rabbits which died was injected into two more rabbits, still after trephining. One of them took rabies on the tenth day, the other on the fourteenth day. The bulb of the first one that died was again injected into a couple of new rabbits, which developed the disease in ten days and twelve days respectively. A fifth time two new animals were inoculated from the first one that died, and they both took the disease on the eleventh day after inoculation; similarly, a sixth passage was made, and gave an incubation of eleven days, twelve days for the seventh passage, ten and eleven for the eighth, ten days for the ninth and tenth passages, nine days for the eleventh, eight and nine days for the twelfth, and so on, with differences of twenty-four hours at the most, until we got to the twenty-first passage, when rabies declared itself in eight days, and subsequently to that always in eight days up to the fiftieth passage, which was only effected a few days ago. That long experimental series which is still going on was begun on November 15, 1882, and will be kept up for the purpose of preserving in our rabies virus that maximum virulence which it has come to now for some considerable time, as it is easy to calculate.

Allow me to call your attention to the ease and safety of the opera-

tions for trephining and then inoculating the virus. Throughout the last twenty months we have been able without a single interruption in the course of the series to carry the one initial virus through a succession of rabbits which were all trephined and inoculated every twelfth day or so.

Guinea-pigs reach more rapidly the maximum virulence of which they are susceptible. The period of incubation is in them also variable and irregular at the beginning of the series of successive passages, but it soon enough fixes itself at a minimum of five days. The maximum virulence in guinea-pigs is reached after seven or eight passages only. It is worth noting that the number of passages required before reaching the maximum virulence, both in guinea-pigs and in rabbits, varies with the origin of the first virus with which the series is begun.

If now this rabies with maximum virulence be transferred again into the dog from guinea-pig or rabbit, there is produced a dog-virus which in point of virulence goes far beyond that of ordinary canine madness.

But, a natural query—of what use can be that discovery as to the existence and artificial production of diverse varieties of rabies, every one of them more violent and more rapidly fatal than the habitual madness of the dog? The man of science is thankful for the smallest find he can make in the field of pure science, but the many, terrified at the very name of hydrophobia, claim something more than mere scientific curiosities. How much more interesting it would be to become acquainted with a set of rabies viruses which should, on the contrary, be possessed of attenuated degrees of virulence! Then, indeed, might there be some hope of creating a number of vaccinal rabies viruses such as we have done for the virus of fowl-cholera, of the microbe of saliva, of the red evil of swine (swine-plague), and even of acute septicæmia. Unfortunately, however, the methods which had served for those different viruses showed themselves to be either inapplicable or inefficient in the case of rabies. It therefore became necessary to find out new and independent methods, such, for example, as the cultivation *in vitro* of the mortal rabies virus.

Jenner was the first to introduce into current science the opinion that the virus which he called the grease of the horse, and which we call now more exactly horse-pox, probably softened its virulence, so to speak, in passing through the cow and before it could be transferred to man without danger. It was therefore natural to think of a possible

diminution of the virulence of rabies by a number of passages through the organisms of some animal or other, and the experiment was worth trying. A large number of attempts were made, but the majority of the animal species experimented on exalted the virulence after the manner of rabbits and guinea-pigs; fortunately, however, it was not so with monkey.

On December 6, 1883, a monkey was trephined and inoculated with the bulb of a dog, which had itself been similarly inoculated from a child who had died of rabies. The monkey took rabies eleven days later, and when dead served for inoculation into a second monkey, which also took the disease on the eleventh day. A third monkey, similarly inoculated from the second one, showed the first symptoms on the twenty-third day, etc. The bulb of each one of the monkeys was inoculated, after trephining, into two rabbits each time. The rabbits inoculated from the first monkey developed rabies between thirteen and sixteen days, those from the second monkey between fourteen and twenty days, those from the third monkey between twenty-six and thirty days, those from the fourth monkey both of them after the twenty-eighth day, those from the fifth monkey after twenty-seven days, those from the sixth monkey after thirty days.

It cannot be doubted after that, that successive passages through monkeys, and from the several monkeys to rabbits, do diminish the virulence of the virus for the latter animals; they diminish it for dogs also. The dog inoculated with the bulb of the fifth monkey gave an incubation of no less than fifty-eight days, although it had been inoculated in the arachnoid space.

The experiments were renewed with fresh sets of monkeys and led to similar results. We were therefore actually in possession of a method by means of which we could attenuate the virulence of rabies. Successive inoculations from monkey to monkey elaborate viruses which, when transferred to rabbits, reproduce rabies in them, but with a progressively lengthening period of incubation. Nevertheless, if one of those rabbits be taken as the first for inoculations through a series of rabbits, the rabies thus cultivated obeys the law which we have seen before, and has its virulence increased at each passage.

The practical application of those facts gives us a method for the vaccination of dogs against rabies. As a starting point, make use of one of the rabbits inoculated from a monkey sufficiently removed from the first animal of the monkey series for the inoculation—hypodermic

or intra-venous—of that rabbit's bulb not to be mortal for a new rabbit. The next vaccinal inoculations are made with the bulbs of rabbits derived by successive passages from that first rabbit.

In the course of our experiments we made use, as a rule, for inoculation, of the virus of rabbits which had died after an incubation of four weeks, repeating three or four times each the vaccinal inoculations made with the bulbs of rabbits derived in succession from one another and from the first one of the series, itself coming directly from the monkey. I abstain from giving more details, because certain experiments which are actually going on allow me to expect that the process will be greatly simplified.

You must be feeling, gentlemen, that there is a great blank in my communication; I do not speak of the micro-organism of rabies. We have not got it. The process for isolating it is still imperfect, and the difficulties of its cultivation outside the bodies of animals have not yet been got rid of, even by the use, as pabulum, of fresh nervous matter. The methods which we employed in our study of rabies ought all the more perhaps, on that account, to fix attention. Long still will the art of preventing diseases have to grapple with virulent maladies the micro-organic germs of which will escape our investigations. It is, therefore, a capital scientific fact that we should be able, after all, to discover the vaccination process for a virulent disease without yet having at our disposal its special virus and whilst yet ignorant of how to isolate or to cultivate its microbe.

As soon as the method for the vaccination of dogs was firmly established, and we had in our possession a large number of dogs which had been rendered refractory to rabies, I had the idea of submitting to a competent committee those of the facts which appeared destined in future to serve as a basis for the vaccination of dogs against rabies. That course was suggested to me in prevision of the later practical application of the method, by the recollection of the opposition with which Jenner's discovery met at its beginning.

I spoke of my project to M. Fallières, the Minister of Public Instruction, who was pleased to approve of it and gave commission to the following gentlemen to control the facts which I had summarily communicated to the Academy of Sciences in its sitting of May 19 last: Messrs. Béclard, Paul Bert, Bouley, Aimeraud, Villemin, Vulpian. M. Bouley was appointed president, Dr. Villemin secretary, and the commission at once set to work. I have the pleasure of informing you

that it has just sent in a first report to the Minister. I was acquainted with it here, and the following are in a few words the facts related in that first report on rabies. I had given to the commission nineteen vaccinated dogs in succession—that is to say, dogs which had been rendered refractory by preventive inoculations. Thirteen only of them had after their vaccination been already submitted to the test-inoculation on the brain.

The nineteen dogs were, for the sake of comparison, divided into sets along with nineteen more control dogs brought from the pound without any sort of selection. To begin with, two refractory dogs and two control dogs were on June 1 trephined and inoculated under the dura-mater, on the surface of the brain, with the bulb of a dog affected with ordinary street rabies.

On June 3 another refractory dog and another control dog were bitten by a furious street mad dog.

The same furious mad dog was on June 4 made to bite still another refractory and another control dog. On June 6 the furious dog which had been utilised on June 3 and 4 died. The bulb was taken out and inoculated, after trephining, into three refractory dogs and three control dogs. On June 10 another street mad dog, having been secured, was, by the commission, made to bite one refractory and one control dog. On June 16 the commission have two new dogs, a refractory one and a control one, bitten by one of the control dogs of June 1, which had been seized with rabies on June 14 in consequence of the inoculation after trephining which it had received on June 1.

On June 19 the commission got three refractory and three control dogs inoculated before their own eyes in the popliteal vein with the bulb of an ordinary street mad dog. On June 20 they have inoculated in their presence, and still in a vein, ten dogs altogether, six of them refractory and four just brought from the pound.

On June 28, the Commission hearing that M. Paul Simon, a veterinary surgeon, had a furious biting mad dog, have four of their dogs, two refractory and two control dogs, taken to his place and bitten by the mad dog.

The Rabies Commission have, therefore, experimented on thirty-eight dogs altogether—namely, nineteen refractory dogs and nineteen control dogs susceptible of taking the disease. Those of the dogs which have not died in consequence of the operations themselves are still under observation, and will long continue to be. The commission, reporting

up to the present moment on their observations as to the state of the animals tried and tested by them, find that out of the nineteen control dogs six were bitten, of which six three have taken rabies. Seven received intra-venous inoculations, of which five have died of rabies. Five were trephined and inoculated on the brain; the five have died of rabies.

On the other hand, not one of the nineteen vaccinated dogs has taken rabies.

In the course of the experiments, on July 13, one of the refractory dogs died in consequence of a black diarrhœa which had begun in the first days of July. In order to ascertain whether rabies had anything to do with it as the cause of death, its bulb was at once inoculated, after trephining, into three rabbits and one guinea-pig. All four animals are still to-day in perfect health, a certain proof that the dog died of some common malady, and not of rabies.

The second report of the Commission will be concerned with the experiments made as to the refractoriness to rabies of twenty dogs to be vaccinated by the Commission themselves.

(*M. Pasteur then announced that he had just received that same morning the first report addressed to M. Fallieres by the Official Commission on Rabies. It states that twenty-three refractory dogs were bitten by ordinary mad dogs, and that not one of them had taken rabies. On the other hand, within two months after the bites, 66 per cent. of the normal dogs similarly bitten had already taken the disease.*)

*November* 1, 1886.—*New Communication on Rabies.*—On October 26, 1885, I acquainted the Academy with a method of prophylaxis of rabies after bites. Numerous applications on dogs had justified me in trying it on man. As early as March 1, 350 persons bitten by dogs undoubtedly mad, and several more by dogs simply suspected of rabies, had already been treated at my laboratory by Dr. Grancher. And in consideration of the happy results obtained it appeared to me that it had become necessary to found an establishment for anti-rabic vaccinations.

To-day, October 31, 1886, 2,490 persons have received the preventive inoculations in Paris alone. The treatment was in the first instance uniform for the great majority of the patients, notwithstanding the different conditions presented by them as to age, sex, the number of bites received, their seat, their depth, and the time which had elapsed

since the occurrence of the accident. It lasted ten days, the patient receiving every day an injection prepared from the spinal marrow of a rabbit, beginning with that of fourteen days' and ending with that of five days' desiccation.

Those 2,490 cases are subdivided according to nationality in the following manner:

| | |
|---|---|
| Russia | 191 |
| Italy | 165 |
| Spain | 107 |
| England | 80 |
| Belgium | 57 |
| Austria | 52 |
| Portugal | 25 |
| Roumania | 22 |
| United States | 18 |
| Holland | 14 |
| Greece | 10 |
| Germany | 9 |
| Turkey | 7 |
| Brazil | 3 |
| India | 2 |
| Switzerland | 2 |
| France and Algeria | 1,726 |

The number of French persons has been considerable, amounting to 1,726, and it will be enough to confine ourselves to the category formed by them as a basis for discussing the degree of efficacy of the method.

Out of the total 1,726 cases treated, the treatment has failed ten times—namely, in the following cases:

The children: Lagut, Peytel, Clédière, Moulis, Astier, Videau.

The woman: Leduc, seventy years old.

The men: Marius Bouvier (thirty years), Clergot (thirty), and Norbert Magnevon (eighteen).

I leave out of count two other persons, Louise Pelletier and Moermann, whose deaths must be attributed to their tardy arrival at the laboratory, Louise Pelletier thirty-six days, and Moermann forty-three days after they had been bitten.

We have therefore ten deaths for 1,726 cases, or 1 in 170; such are, for France and Algeria, the results of the first year's application of the method.

Those statistics, taken as a whole, demonstrate the efficacy of the treatment, as proved further by the relatively large number of deaths which occurred amongst bitten persons who had not been vaccinated.

# PSYCHOLOGY

DESCRIPTIONS of the mind or soul begin with Plato and Aristotle. Locke may be called the father of psychology of modern times. The Germans tried to add exactness to psychology by an experimental method. Lotze in 1852, Fechner in 1860 and Wundt in 1863 all did much to bring this experimental point of view to a practical working basis. A great many facts have been discovered by laboratory methods and such investigations are still being pursued.

In 1861 Broca discovered that the brains of persons suffering one kind of aphasia showed a lesion in a certain spot.

About 1870 Hitzig showed that special movements could be excited in a dog by electrification of various parts of the brain. By this method and by comparing the injuries in the brains of persons suffering from nervous disorders, Ferrier and Munk, six or seven years later, established local centers for the senses of sight, hearing, touch, and smell. All of this introduced an entirely new conception of the relation of brain and mind. Briefly put, the facts are these: destroy a center in the brain and you destroy the corresponding sense or motion; destroy the path between two centers and the relation between corresponding ideas is destroyed; thus a patient may see his coat and not know what it is for. Moreover, not only does a lesion destroy the power of sight, for example, but *takes away the memory of things seen.* The question of localization is one of the most interesting in psychology, and has already made possible surgical operations on the brain for diseases which previous ages did not connect with the brain at all.

# DAVID FERRIER

David Ferrier was born at Aberdeen, Scotland, in 1843. In 1863 he graduated from the University of Aberdeen with the highest honors and in the same year won the Ferguson scholarship in classics and philosophy, open for competition to graduates of the four Scotch Universities. In 1854 he entered the University of Heidelburg, where he carried on his psychological studies and began to study anatomy, physiology, and chemistry; in 1865 he began the study of medicine at the University of Edinburg, where he graduated in 1868 after having won several medals. He remained at the university as assistant to the Professor of the Practice of Physic until 1869, and the year following, assisted a practitioner at Bury, St. Edmunds, where he managed to still prosecute his researches on the comparative anatomy and histology of the brain. In 1871 he was appointed Demonstrator of Physiology in King's College, and in 1872 Professor of Forensic Medicine in the same institution, succeeding Dr. Grey, whom he had assisted in preparing the fourth and fifth editions of his *Principles of Forensic Medicine*. He retained this position until 1889. He also became junior physician to the West London Hospital in 1872, assistant physician to King's College Hospital in 1874, and full physician in 1880. He was assistant physician to the Hospital for Paralysis and Epilepsy, Regent's Park, from 1877 to 1880, when he was appointed physician to the National Hospital for the Paralyzed and Epileptic. He has published numerous memoirs. Dr. Ferrier's chief scientific work has been connected with the brain. He proved that the senses and powers of movement were closely connected with definite centers in the brain; that the destruction of these centers would destroy the corresponding mental power and not only would the sense itself be destroyed, but the memory of past sensations corresponding to the injured center. He was one of the founders and is still editor of the journal *Brain*.

## LOCALIZATION OF THE FUNCTIONS IN THE BRAIN

Hitherto we have considered the brain chiefly in its objective or physiological aspects, and the conclusion has been arrived at that the brain is a complex system of centres of motion and centres of sensation.

In their subjective aspect the functions of the brain are synonymous with mental operations, the consideration of which belongs to the science of psychology and the subjective method of investigation. No purely physiological investigation can explain the phenomena of consciousness. By throwing light, however, on the anatomical substrata of consciousness, physiological experiment may serve to elucidate some of the at present obscure relations between normal and abnormal conditions of the brain, and normal and abnormal psychical manifestations.

It is not the object of this work to attempt an analysis of mind or the laws of mental operations, but simply to discuss, in the light of the facts revealed by the experimental investigations recorded in the preceding chapters, some of those relations between the physiological and psychological functions of the brain which present themselves to the consideration of the physician and medical psychologist.

That the brain is the organ of the mind, and that mental operations are possible only in and through the brain, is now so thoroughly well established and recognized that we may without further question start from this as an ultimate fact.

But how it is that molecular changes in the brain cells coincide with modifications of consciousness; how, for instance, the vibrations of light falling on the retina excite the modification of consciousness termed a visual sensation, is a problem which cannot be solved. We may succeed in determining the exact nature of the molecular changes which occur in the brain cells when a sensation is experienced, but this will not bring us one whit nearer the explanation of the ultimate nature of that which constitutes the sensation. The one is objective and the other subjective, and neither can be expressed in terms of the other. We cannot say that they are identical, or even that the one passes into the other; but only, as Laycock expresses it, that the two are correlated, or, with Bain, that the physical changes and the psychical modifications are the objective and subjective sides of a "double-faced unity."

"We have every reason for believing that there is, in company with

all our mental processes, *an unbroken material succession.* From the ingress of a sensation, to the outgoing responses in action, the mental succession is not for an instant dissevered from a physical succession. A new prospect bursts upon the view; there is a mental result of sensation, emotion, thought, terminating in outward displays of speech or gesture. Parallel to this mental series is the physical series of facts, the successive agitation of the physical organs. . . . While we go the round of the mental circle of sensation, emotion and thought, there is an unbroken physical circle of effects. It would be incompatible with everything we know of cerebral action, to suppose that the physical chain ends abruptly in a physical void, occupied by an immaterial substance; which immaterial substance, after working alone, imparts its results to the other edge of the physical break, and determines the active response—two shores of the material, with an intervening ocean of the immaterial. There is, in fact, no rupture of nervous continuity. The only tenable supposition is, that mental and physical proceed together, as undivided twins. When, therefore, we speak of a mental cause, a mental agency, we have always *a two-sided cause;* the effect produced is not the effect of mind alone, but of mind in company with body." (Bain, "Mind and Body," 1873, p. 131.)

In accordance with this position it must follow from the experimental data that mental operations in the last analysis must be merely the subjective side of sensory and motor substrata. This view has been repeatedly and clearly enunciated by Hughlings-Jackson, with whose physiological and psychological deductions from clinical and pathological data I frequently find myself in complete accordance. ("Clinical and Physiological Researches on the Nervous System." Reprints from "Lancet," 1873.)

The physiological activity of the brain is not, however, altogether co-extensive with its psychological functions. The brain as an organ of motion and sensation, or presentative consciousness, is a single organ composed of two halves; the brain as an organ of ideation, or re-presentative consciousness, is a dual organ, each hemisphere complete in itself. When one hemisphere is removed or destroyed by disease, motion and sensation are abolished unilaterally, but mental operations are still capable of being carried on in their completeness through the agency of the one hemisphere. The individual who is paralysed as to sensation and motion by disease of the opposite side of the brain (say the right), is not paralysed mentally, for he can still feel and will and think, and intelligently comprehend with the one hemisphere. If these functions are not carried on with the same vigour as before, they at least do not appear to suffer in respect of completeness.

In order that impressions made on the individual organs of sense

shall excite the subjective modification called a sensation, it is necessary that they reach and induce certain molecular changes in the cells of their respective cortical centres.

If the angular gyrus (gyri) is destroyed or functionally inactive, impressions made on the retina and optical apparatus cause the same physical modifications as usual, but do not affect consciousness. The changes produced have no subjective side.

The optical apparatus without the angular gyrus may be compared to the camera without the sensitised plate. The rays of light are focussed as usual, but produce no chemical action, and leave no trace when the object is withdrawn, or the light from it shut off. The angular gyrus is like the sensitive plate. The cells undergo certain molecular modifications which coincide with certain subjective changes constituting the consciousness of the impression or special visual sensation. And as the sensitive plate records, in certain chemical decompositions, the form of the object presented to the camera, so the angular gyrus records in cell modifications the visual characters of the object looked at. We may push the analogy still further. Just as the chemical decomposition effected by the rays of light may be fixed and form a permanent image of the object capable of being looked at, so the cell modifications which coincided with the presentation of the object to the eye, remain permanently, constituting the organic memory of the object itself. When the same cell modifications are again excited, the object is re-presented or rises up in idea. It is not meant by this analogy that the objects are photographed in the angular gyrus, as objects are photographed on the plate, but merely that permanent cell modifications are induced, which are the physiological representatives of the optical characters of the object presented to the eye. The optical characters are purely light vibrations, and few objects are known by these alone. The object appeals to other senses, and perhaps to movements, and the idea of the object as a whole is the revival of the cell modifications in each of the centres concerned in the act of cognition. For what is true of the angular gyrus or sight centre is true, *mutatis mutandis,* of the other sensory centres. Each is the organic basis of consciousness of its own special sensory impressions, and each is the organic basis of the memory of such impressions in the form of certain cell modifications, the reinduction of which is the re-presentation or revival in idea of the individual sensory characters of the object. The organic cohesion of these elements by association renders it possible for the re-excitation of the one set of characters to recall the whole.

The sensory centres, therefore, are to be regarded not merely as the organs of consciousness of immediate sensory impressions, but as the organic register of special sensory experiences. This organic memory is the physical basis of Retentiveness, and the property of re-excitability is the organic basis of Recollection and Ideation. We have thus a physiological foundation of the law arrived at on other grounds by Bain, *viz.* that "the renewed feeling occupies the very same parts, and in the same manner as the original feeling." According to Spencer, the renewal of the feeling is the *faint* revivification of the same processes which are *strongly* excited by presentation of the object. The molecular thrill, if we may so term it, of present sensation extending from the peripherical organ of sense, is in the ideal sensation revived, but, as a rule, not so powerfully as to extend to the periphery; though, in rare instances, the central revivification may be so intense as actually to re-induce the peripherical impression. This occurs in certain morbid states such as are described under the name of "fixed ideas," or in sensory hallucinations from diseased conditions of the brain, as in epilepsy and insanity.

The organic memory of sensory impressions is the fundamental basis of knowledge. If the sense impressions were evanescent, or endured only so long as the object was present, the range of conscious intelligent action would be limited to the present, and we should have no real knowledge. Knowledge implies the consciousness of agreement or difference. We can only be said to *know* when we recognise identity, or difference between past and present conscious modifications. We know that a certain colour is green by recognising a similarity or identity between the present and a certain past colour sensation, or a difference between this and some other colour in the spectrum. If we had no organic memory of the past capable of re-excitation to serve as the basis of comparison, we should be unable to recognise either agreement or difference. We might be conscious from moment to moment, but there would be no continuation in time, and knowledge would be impossible. The foundation of the consciousness of agreement is the re-excitation by the present of the same molecular processes which coincided with a past impression; and of difference, a transition from one physical modification to another. The sensory centres, therefore, besides being the organs of sensation or consciousness of immediate impressions, contain, in the persistence and revivability of the coincident physical modifications, the materials and possibilities of simple and complex cognitions, in so far as these are dependent on sensory experience alone.

The destruction of the sight centre, therefore, not only makes the individual blind presentatively, but blind re-presentatively or ideally, and *all memories into which visual characters enter in part or whole become mangled and imperfect, or are utterly rooted out of consciousness.* The destruction of the eye renders the individual blind only presentatively, but his visual memory and visual ideation remain unaffected. And it would be extremely interesting to ascertain whether, in an individual born blind, the sight centre presents any peculiarities either as regards the forms of the cells, or their processes or otherwise, differing from those of the normal brain. If such were detectable, we should come near arriving at the characters of the physical basis of an idea.

In the remarkable and, in a physio-psychological sense, highly instructive condition termed aphasia, many of the principles above laid down are strikingly exemplified.

The subject of aphasia is deprived of the faculty of articulate speech, and also very generally of the faculty of expressing his thoughts in writing, while he continues intelligently to comprehend the meaning of words spoken to him, or, it may be, to appreciate the meaning of written language. An aphasic individual knows perfectly well, as exhibited by his gestures, if a thing is called by its right name or not, but he cannot utter the word himself, or write it when it is suggested to him. In his attempts, only an automatic or interjectional expression or some unintelligible jargon escapes his lips, or unmeaning scrawls are set down on paper as writing.

This affection is usually, at first at least, associated with a greater or less degree of right hemiplegia, but the motor affection of the right side, chiefly of the right arm, is often slight and transient, or may be wanting from the first, the only indication of motor paralysis being a paretic or weak condition of the oral muscles of the right side.

The inability to speak is not due to paralysis of the muscles of articulation, for these are set in action and employed for purposes of mastication and deglutition by the aphasic individual.

The cause of this affection was shown by Broca—and his observations have been confirmed by thousands of other cases—to be associated with disease in the region of the posterior extremity of the third left frontal convolution, where it abuts on the fissure of Sylvius, and overlaps the island of Reil, a region which I have shown corresponds with the situation of the motor centres of articulation in the monkey.

One of the most common causes of the affection is softening of this

region, consequent on sudden stoppage of the circulation by embolic plugging of the arterial channels which convey its blood supply, by which the functional activity of the part is temporarily or permanently suspended.

Owing to the proximity and common vascular supply of the motor centres of the hand and facial muscles, it is easy to see how they also become implicated in the lesion of the centres of articulation, and why, therefore, dextral and facial motor paralysis should so commonly occur along with aphasia. This may be taken as further evidence in proof of the fact that lesions of the cortical motor centres cause motor paralysis on the opposite side.

The escape of the articulatory muscles from paralysis in unilateral lesion of the centres of articulation is accounted for by the bilateral influence of each centre which has been experimentally demonstrated.

The loss of speech actually or in idea from destruction of the centres of articulation is not more difficult of explanation on the principles laid down in this chapter, than the loss of sight presentatively or representatively from destruction of the angular gyri. That which constitutes the apparent difficulty is the explanation of speechlessness without motor paralysis from unilateral lesion of the centres of articulation in the left hemisphere.

This difficulty is explicable on the principles laid down in reference to motor acquisitions in general. As the right side of the body is more especially concerned in volitional motor acts, so the education is principally in the motor centres of the left hemisphere, and these centres are more especially the organic basis of motor acquisitions. The left articulatory centres, as has been argued by more than one observer, preponderate over the right in the initiation of motor acts of articulation. They are, therefore, more especially the organic basis of the memory of articulations and of their revival in idea. The destruction of the left articulatory centres removes the motor limb of the cohesions which have been formed by long education between the centres of hearing and sight, and between the centres of ideation in general.

Sounds actual or revived fail to excite corresponding articulations actually or in idea. The individual is speechless, the motor part of the sensori-motor cohesion, sound-articulation, being broken. The sight of written symbols also fails to reproduce the equivalent articulatory action, actually or in idea. The individual is speechless, because the motor element of the sensori-motor cohesion, sight-articulation, is broken.

Ideally revived sights, sounds, touches, tastes, smells fail to call up

the symbolic articulations, hence the individual cannot express his ideas in language, and in so far as language or internal speech is necessary to complex trains of thought, in that proportion is thought impaired. Thought, however, may be carried on without language, but it is thought in particulars, and is as cumbrous and limited as mathematical calculations without algebraical symbols. Thought, as has been observed by Bain, is in a great measure carried on by internal speech, *i. e.*, through the ideal or faint re-excitation of the articulatory processes which are symbolic of ideas. This is shown by the unconsciously executed movements of the lips and tongue which all persons exhibit more or less, and some so obviously that the unconscious processes rise almost to the point of whispering. So also the blind deaf-mute Laura Bridgman, whose language was symbolic movements of the fingers, during thought or when dreaming, unconsciously executed the same movements as she was accustomed to make in the actual exercise of her manual speech.

And just as ideas tend to excite their symbolic representations in articulation or in manual movements, so does the actual or ideal revival of the articulatory or manual movements tend by association to call up the other limbs of the cohesions, whether simple sights, sounds, tastes, smells, or their combinations. The importance of this connection between the articulating centres and the centres of ideation in general, will be shown more fully in reference to the voluntary revival of ideas and control of ideation.

We have seen that a person aphasic from destruction of his speech centre (as we may for shortness call the articulatory motor centres of the left hemisphere) still remains capable of appreciating the meaning of words uttered in his hearing. In this respect he does not (and there is no reason why he should) differ from a normal individual. His centres of sight, hearing, etc., being unimpaired, he is as capable as before of sight, auditory, tactile, gustatory and olfactory ideation. The difference consists in the fact that in the aphasic individual the word spoken, though it calls up the idea or meaning, cannot call up the word itself actually or in idea, owing to the centres of word execution and word ideation being destroyed. The appreciation of the meaning of spoken words is readily accounted for by the fact that in the process of education an association is formed directly between certain sounds and certain objects of sense, simultaneously with, if not antecedent to, the formation of the cohesive association between these sounds and certain acts of articulation. The cohesion or association between sound and meaning remains unimpaired in aphasia; it is the cohesion between

sound and articulation which is broken, by removal of the motor factor of the organic nexus.

The association between visible symbols and things signified is, however, secondary to the associations formed between sounds and things signified, and between sounds and articulations, for speech precedes the art of writing. In the first instance, when an individual is learning to read, visible symbols are translated into articulations and revived sounds before they call up the things signified. This translation occurs in all at first, and continues apparent in those persons not much accustomed to reading, for they only understand by articulating in a more or less suppressed manner all the while. Just as an individual in learning a foreign language is at first obliged to translate the words into his vernacular before he reaches the meaning, but comes by familiarity and practice to associate the new words with their meaning directly without the aid of the vernacular, and even to think in the new language, so it is possible that by long experience in reading, a direct association may be established between visible symbols and things signified, without the mediation of articulation. In such a case a person who has his speech centre disorganised will still be able to comprehend the meaning of written language. A person, on the other hand, who has not established the direct association between visible symbols and things signified, and is still obliged to translate through articulation, will, by destruction of his speech centre, fail to comprehend written language, though he may still understand spoken language.

In learning to write a new association has to be grafted on to the association already formed between sounds and articulations. The new cohesion is between sounds and certain symbolic manual movements guided by sight, which symbolic tracings are the equivalents of certain acts of articulation. In the first instance this association between sounds, or sounds and things signified, and manual movements, takes place through the mediation of the centres of articulation, for the sounds or ideas are first reproduced actually or internally by articulations before their equivalence in written symbols is established and recognised.

By education, and by the familiarity engendered of long practice in expressing ideas by written symbols, a direct association becomes established between sounds and ideas, and symbolic manual movements, without the intermediation of articulation; and in proportion as the translation through articulation is dispensed with, in that proportion will an individual continue able to write who is aphasic from disease of his speech centre.

In the great majority of cases of aphasia, met with in hospitals, the direct association between sounds and ideas and manual equivalents of articulations has not been established, except for very simple and constantly repeated acts of writing such as signing one's name: and hence, as the intervention of articulation is still necessary before ideas can be expressed in writing, destruction of the speech centre causes not merely aphasia, but also *agraphia*.

Examples of all these different conditions are to be met with in aphasia. Some can neither speak nor write; some can write but cannot speak; some can write their names but cannot write anything else; all can comprehend spoken language; many can comprehend written language; others not at all, or very imperfectly. Between the normal condition of the speech centre and its total destruction, many intermediate abnormal conditions occur, which exemplify themselves as partial aphasia, and partial disorders of speech. In some cases there seems to be such a perturbation of the centres, that though the individual is not aphasic in the sense of being speechless, yet the associations between certain articulations and certain ideas are so disturbed that in attempts to speak only an incoherent jumble of words comes forth. This is a condition of ataxia rather than aphasia in the proper sense of the term.

The speech centre is, as has been stated, in the great majority of instances situated in the left hemisphere. But there is no reason, beyond education and heredity, why this should necessarily be so. It is quite conceivable that the articulating centres of the right hemisphere should be educated in a similar manner. A person who has lost the use of his right hand may by education and practice acquire with his left all the cunning of the right. In such a case the manual motor centres of the right hemisphere become the centres of motor acquisitions similar to those of the left. As regards the articulating centres, the rule seems to be that they are educated, and become the organic seat of volitional acquisitions on the same side as the manual centres. Hence, as most people are right-handed, the education of the centres of volitional movements takes place in the left hemisphere. This is borne out in a striking manner by the occurrence of cases of aphasia with left hemiplegia in left-handed people. Several cases of this kind have now been put on record. (*Vide* Thèse Mongié, Paris, 1866; quoted by Lépine, "La Localisation dans les Maladies Cérébrales," Paris, 1875. Russell, "Med. Times and Gazette," July 11, Oct. 24, 1874. Case (unpublished) communicated to me by my friend Dr. Lauder Brunton, of St. Bartholomew's Hospital.)

These cases more than counterbalance any exception to the rule that the articulating centres are educated volitionally on the same side as the manual motor centres. The rule need not be regarded as absolute, and we may admit exceptions without invalidating a single conclusion respecting the pathology of aphasia as above laid down.

Though the left articulatory centre is the one commonly and specially educated in speech, it is quite conceivable that a person who has become aphasic by reason of total and permanent destruction of the left speech centre, may reacquire the faculty of speech by education of the right articulatory centres. To a certain extent they have undergone education along with those of the left through associated action, registering automatically, as Hughlings-Jackson puts it, the volitional acts of the left. This automatic may be educated into volitional power, though at the age at which aphasia usually occurs, there is less capacity and plasticity in the nerve centres for forming new cohesions and associations. The rapid recovery which so frequently occurs in cases of aphasia, especially of the kind due to embolic plugging of the nutrient arteries of the left centres, is not so much to be regarded as an indication of the education of the right centres, but rather of the re-establishment of the circulation and nutrition in parts only temporarily rendered functionless.

But there are other cases which would seem to show that recovery of speech may take place after a lesion which has caused complete and permanent destruction of the left speech centre. A case which seems to me to be of this nature has been reported by Drs. Batty, Tuke and Fraser ("Journal of Mental Science," April, 1872), who, however, have adduced it as an instance opposed to the localisation of a speech centre, which in one sense, *i. e.,* as against absolute unilateral localisation, it certainly is. The case in essentials is that of a female patient who was rendered unconscious by the occurrence of cerebral hemorrhage. On her recovery she was found totally speechless, and she remained so for an indefinite period. In process of time, however, the faculty of speech was restored in great measure, though never quite perfectly. "During the whole period of her residence two peculiarities in her speech were observed—a thickness of articulation resembling that of general paralysis, and a hesitancy when about to name anything, the latter increasing very much some months previous to her death.

"The thickness seemed apparently due to slight immobility of the upper lip when speaking, but there was no paralysis when the lip was

voluntarily compressed against its fellow. The inaction of the upper lip was observed by all.

"The hesitancy was most marked when she came to a noun, the hiatus varying in duration according to the uncommonness of the word. Latterly, she could not recall even the commonest terms, and periphrases or gestures were used to indicate her meaning. She was always relieved and pleased if the words were given her, when she invariably repeated them. For example, she would say, 'Give me a glass of ——.' If asked if it was 'water?' she said, 'No.' 'Wine?' 'No.' 'Whisky?' 'Yes, whisky.' *Never did she hesitate to articulate the word when she heard it.*"

Death occurred fifteen years after the seizure, and it was found *post mortem* that there was total destruction and loss of substance in the cortical region in the left hemisphere corresponding with the position of the centres of articulation. This seems to me one of the clearest cases of re-acquisition of the faculty of speech by education of the articulating centres of the right side. That speech was lost in the first instance is in harmony with the usual effect of lesion of the left speech centre. Education of the right side had not become quite perfect even after fifteen years, and that peculiar hesitancy, and the fact, which the authors themselves have specially noted in italics, that speech often required the aid of suggestion, is in accordance with the less volitional and greater automatic power of the right hemisphere. Aphasia being essentially due to the destruction, temporary or permanent, of the centres of excitation and organic registration of acts of articulation, is a significant proof of the fact that there is no break between the physiological and psychological functions of the brain, and that the objective and subjective are not separated from each other by an unbridgeable gulf.

We have now traced the development of the volitional control of the movements, and the mode in which the memory of volitional acts becomes organised in the motor centres. The conclusion reached is that the volitional control of the movements becomes established when an organic cohesion is welded between a consciously discriminated feeling and a definite and differentiated motor act. The volitional control of the individual movements having once been established the work of education advances, and the conditions of volition become more and more complex. The volition of the untutored and inexperienced infant is of a more or less impulsive character, its action being conditioned mainly by impressions or ideas of the moment. Associations have not yet been formed between the pleasurable and painful remote consequences of actions. *Experientia docet.* A child which has acquired the differentiated control of its hands is impelled to touch and handle whatever

strongly attracts its sight. The sight of a bright flame stimulates a desire to handle it. This is followed by severe bodily pain, and an association is formed between touching a certain brilliant object and severe suffering. The vivid memory of pain experienced on a former occasion, is sufficient to counteract the impulse to touch when the child is again placed in similar circumstances. Here we have a simple case of the conflict of motives, and the inhibition or neutralisation of one motive by another and stronger. Action, if it results at all, is conditioned by the stronger. Similarly, a hungry dog is impelled by the sight of food to seize and eat. Should the present gratification bring with it as a consequence the severe pain of a whipping, when certain articles of food have been seized, an association is formed between eating certain food and severe bodily pain; so that on a future occasion the memory of pain arises simultaneously with the desire to gratify hunger, and, in proportion to the vividness of the memory of pain, the impulse of appetite is neutralised and counteracted. The dog is said to have learnt to curb its appetite.

As experience increases, the associations between acts and consequences increase in complexity. Both by personal experience, as well as by the observed experience and testimony of others, associations are established between actions and their remote consequences as pleasures or pains, and it is found that present gratification may bring a greater and future pain, and actions causing present pain may bring a greater pleasure. As the great law of life is *vivere convenientur naturae*—to secure pleasure and avoid pain in the highest and most general sense, and not for the moment only (a law which cannot be transgressed with impunity)—actions are conditioned no longer, as in the infant or untutored animal, by present desires or feelings alone, but by present desires modified by the ideally revived feelings of plasure or pain near and remote, which experience has associated with definite actions. The motive to action is thus the resultant of a complex system of forces; the more complex, the wider the experience, and the more numerous the associations formed between actions and their consequences, near and remote. Actions so conditioned are regarded as mature or deliberate, in contradistinction to impulsive volitions, but the difference is not in kind, but only in degree of complexity; for in the end, actions conditioned by the resultant of a complex system of associations are of essentially the same character as those conditioned by the simple stimulus of a present feeling or desire, where no other associations have as yet been formed capable of modifying it.

But what is normal in the infant or untutored animal, may be positive insanity on the part of the educated adult. If in him actions are conditioned merely by present feelings or desires, irrespective of, or in spite of, the associations formed by experience between such acts and their consequences as pains, there is a reversion to the infantile type of volition; the only difference being, that in the one case no opposing associations have as yet been formed, while in the other, though formed, they prove of no avail. An individual who so acts, acts irrationally; and if in anyone, notwithstanding the opposing influence of past associations, a present feeling or desire reaches such a pitch of intensity as to overbalance these associations, the individual is said to act in spite of himself, or, metaphorically, against his will. Such tendencies occur more or less in all, but they are exemplified more especially in certain forms of insanity, in which the individual becomes the victim of some morbid desire, and is impelled irresistibly, and to his horror, to commit some act fraught with dreadful consequences.

The tendency of feelings or desires to expend themselves in action leads to the consideration of another faculty which plays an important part in the regulation and control of ideation and action.

The primordial elements of the volitional acts of the infant, and also of the adult, are capable of being reduced in ultimate physiological analysis to reaction between the centres of sensation and those of motion.

But besides the power to act in response to feelings or desires, there is also the power to inhibit or restrain action, notwithstanding the tendency of feelings or desires to manifest themselves in active motor outbursts.

Inhibition of action is either direct or indirect.

As an example of indirect inhibition, we may take the inhibition of reflex action, which is caused by a simultaneous stronger sensory stimulus. This is paralleled in volitional action by the inhibition or neutralisation of one motive by another and stronger.

As an example of direct inhibition, we may take the inhibitory action of the vagus upon the heart. This is due to an influence of the vagus on the cardiac motor ganglia by which their activity is restrained. "The heart contains within itself numerous ganglia, which keep up its rhythmical contractions even for some time after it has been removed from the body. The terminal branches of the vagus nerve in the heart are connected in some way with these ganglia, and whenever it is irritated the ganglia cease to act on the muscular substance, and the heart stands completely still in a relaxed condition. The branches of the

vagus which have this action resemble motor nerves in their conveying an irritation applied to them towards the periphery, and not towards the centre, and also in their origin, for although they run in the vagus they are really derived from the spinal accessory nerve, and only join the vagus near its origin. The other fibres of the spinal accessory go to muscles, and when they are excited they set the muscles in action, but those going to the heart do not end in the muscular fibres, but in the ganglia, and they produce rest instead of motion, relaxation instead of contraction." (Lauder-Brunton, "On Inhibition, Peripheral and Central," "West Riding Lunatic Asylum Medical Reports," vol. iv., p. 181.) The centres of direct inhibition are thus truly motor in character, but their action is expended in the motor centres proper.

As an illustration of volitional inhibition we may take the power, accompanied with the feeling of effort, to rein in and inhibit the tendency of powerful feelings to exhibit themselves in action. The battle between inhibition and the tendency to active motor outburst, is indicated by the tension into which the muscles are thrown, and yet kept reined in, so that under a comparatively calm exterior there may be a raging fire, threatening to burst all bonds.

The inhibitory centres are not equally developed or educated in all, nor are they equally developed in the same individual in respect to particular tendencies to action. But this faculty of inhibition appears to me to be a fundamental element in the attentive concentration of consciousness and control of ideation.

It has been properly remarked that we have no direct volitional control over the centres of ideation. Ideas once excited centrally or from peripherical impressions tend to excite each other in a purely reflex manner, as Laycock and Carpenter have pointed out. Left to themselves ideas excite ideas along the lines of association of contiguity and similarity—coherently in the waking state, when all the centres and senses are functionally active; incoherently in dreams and delirium, where the various centres are functioning irregularly.

But we have the power of concentrating attention on one idea, or class of ideas, and their immediate associates, to the exclusion of all others, a power differently developed in different individuals. We can thus modify and control the current of ideation, and we can also, to a certain extent, voluntarily call up and retain in consciousness particular ideas and particular associations of ideas.

On what physiological basis this psychological faculty rests is an extremely difficult question, and is one scarcely capable of experimental

determination. The following considerations are therefore more properly speculations than deductions from experimental data.

Both the voluntary excitation of ideas and the concentration of consciousness by which the current of ideation is controlled, seem to be essentially dependent on the motor centres. The fact that attention involves the activity of the motor powers has been clearly enunciated by Bain and Wundt.

Bain ("The Emotions and the Will," 3rd ed. 1875) remarks as follows:—"It is not obvious at first sight that the retention of an idea in the mind is operated by voluntary muscles. Which movements are operating when I am cogitating a circle, or recollecting St. Paul's? There can be no answer given to this, unless on the assumption that the mental or revived image occupies the same place in the brain and other parts of the system as the original sensation did, a position supported by a number of reasons adduced in my former volume ("Contiguity," §10). Now there being a muscular element in our sensations, especially of the higher senses—touch, hearing, sight—this element must somehow or other have a place in the after remembrance of the idea.

"The ideal circle is a restoring of those currents that would prompt the sweep of the eye round an ideal circle; the difference lies in the last stage, or in stopping short of the actual movement performed by the organ" (p. 370).

In these sentences, and particularly the last, Bain seems to me to have clearly indicated the elements of attention, which I conceive to be a combination of the activity of the motor, and of the inhibitory-motor centres.

In calling up an idea, or when engaged in the attentive consideration of some idea or ideas, we are in reality throwing into action, but in an inhibited or suppressed manner, the movements with which the sensory factors of ideation are associated in organic cohesion.

We think of form by initiating and then inhibiting the movements of the eyes or hands through which and by which ideas of form have been gained and persist. And just as sensory impressions or sensory ideas tend by association to call up ideal or actual movements, so conversely, the excitation of movements tends to call up by association the various sensory factors which combine with these particular movements to form complex ideas. In the case of ideas, the motor element of which is not apparent, the method of excitation can be referred to the articulatory movements with which as symbols ideas are associated. This is, in fact, the most usual method of recalling ideas in general. We recall an object in idea by pronouncing the name in a suppressed manner. We think, therefore, and direct the current of thought in a great measure by means of internal speech.

This is essentially the case with respect to the recalling of abstract ideas as contradistinguished from concrete and particular.

The abstract qualities and relations of objects exist only by reason of words, and we think of the concrete or particular instances out of which the general or abstract have been formed, by making the symbolic movements of articulation with which these ideas cohere.

An aphasic individual is incapable of abstract ideation or trains of thought. He thinks only in particulars, and his thoughts are conditioned mainly by present impressions on his organs of sense, arousing ideas according to the usual laws of association.

The recall of an idea being thus apparently dependent on excitation of the motor element of its composition, the power of fixing the attention and concentrating consciousness depends, further, on inhibition of the movement.

During the time we are engaged in attentive ideation we suppress actual movements, but keep up in a state of greater or less tension the centres of the movement or movements with which the various sensory factors of ideation cohere.

By checking the tendency to outward diffusion in actual motion, we thereby increase the internal diffusion, and concentrate consciousness. For the degree of consciousness is inversely proportional to the amount of external diffusion in action. In the deepest attention, every movement which would diminish internal diffusion is likewise inhibited. Hence, in deep thought, even automatic actions are inhibited, and a man who becomes deep in thought while he walks, may be observed to stand still.

The excitation of the motor centres, inhibited from external diffusion, expends its force internally along the lines of organic cohesion, and the various factors which have become organically coherent with any particular movement rise into consciousness. This inhibited excitation of a motor centre may be compared to tugging at a plant with branching roots. The tension causes a vibratile thrill to the remotest radicle. So the tension of the motor centre keeps in a state of conscious thrill the ideational centres organically coherent therewith. The centres of inhibition would therefore form the chief factor in the concentration of consciousness and the control of ideation. They have, however, no self-determining power of activity, but are called into action by the same stimuli which tend to excite actual movement. The centres of inhibition undergo education along with the centres of actual motion

during the growth of volition. The education of the centres of inhibition introduces the element of deliberation into volition, for action at the instigation of present feelings is suspended until the various associations which have clustered round any individual act have arisen in consciousness. The resultant of the various associations, the revival of which is conditioned by the present feeling and the concentration of consciousness which it instigates, is the motive which ultimately determines the action.

In proportion to the development and degree of education of the centres of inhibition do acts of volition lose their impulsive character, and acquire the aspect of deliberation. Present impulses or feelings, instead of at once exciting action, as in the infant, stimulate the centres of inhibition simultaneously, and suspend action until, under the influence of attention, the associations engendered by past experience between actions and their pleasurable or painful consequences, near and remote, have arisen in consciousness. If the centres of inhibition, and thereby the faculty of attention, are weak, or present impulses unusually strong, volition is impulsive rather than deliberate.

The centres of inhibition being thus the essential factor of attention, constitute the organic basis of all the higher intellectual faculties. And in proportion to their development we should expect a corresponding intellectual power.

"A great profusion of remembered images, ideas, or notions, avails little for practical ends without the power of arrest or selection, which in its origin is purely voluntary. We may have the luxuriousness of a reverie or a dream, but not the compliance with a plan of operations, or with rules of composition." (Bain, p. 371.)

In proportion to the development of the faculty of attention are the intellectual and reflective powers manifested. This is in accordance with the anatomical development of the frontal lobes of the brain, and we have various experimental and pathological data for localising in these the centres of inhibition, the physiological substrata of this psychological faculty.

It has already been shown that electrical irritation of the antero-frontal lobes causes no motor manifestations, a fact which, though a negative one, is consistent with the view that, though not actually motor, they are inhibitory-motor, and expend their energy in inducing internal changes in the centres of actual motor execution.

Centres of direct inhibition and nerves of inhibition are, as we have seen, all centrifugal, or motor, in character, and it has also been shown that the frontal regions are directly connected with the centrifugal, or motor, tracts of the peduncular expansion or corona radiata.

The removal of the frontal lobes causes no motor paralysis, or other evident physiological effects, but causes a form of mental degradation, which may be reduced in ultimate analysis to loss of the faculty of attention.

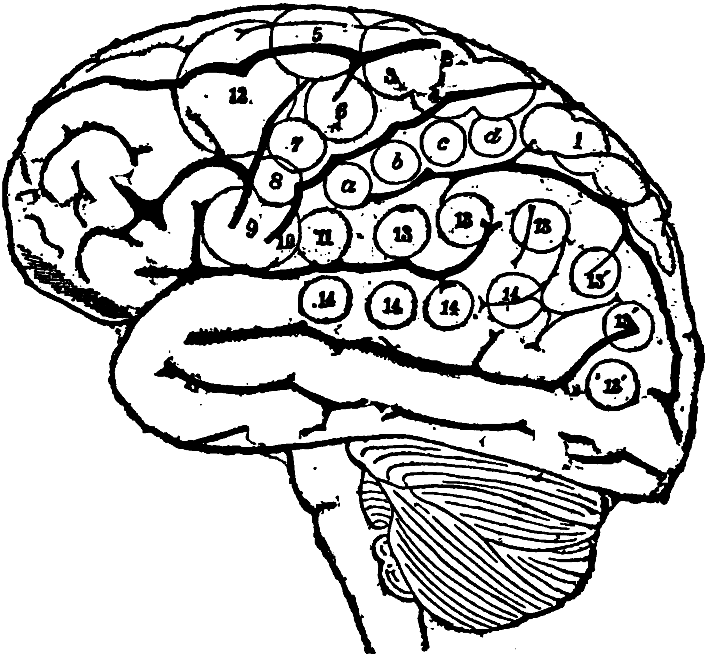
The powers of attention and concentration of thought are, further, small and imperfect in idiots with defective development of the frontal lobes, and disease of the frontal lobes is more especially characteristic of dementia or general mental degradation. The frontal regions which correspond to the non-excitable regions of the brain of the monkey are small or rudimentary in the lower animals, and their intelligence and powers of reflective thought correspond.

The development of the frontal lobes is greatest in man with the highest intellectual powers, and taking one man with another, the greatest intellectual power is characteristic of the one with the greatest frontal development.

The phrenologists have, I think, good grounds for localising the reflective faculties in the frontal regions of the brain, and there is nothing inherently improbable in the view that frontal development in special regions may be indicative of the power of concentration of thought and intellectual capacity in special directions.

In this chapter I have contented myself with indicating very briefly some of the more important psychological principles which seem to me fairly deducible from experimental investigation into the anatomical and physiological substrata of mind, principles which in many respects coincide with those expounded by Bain and Herbert Spencer.

Many other important points in cerebral physiology still remain to be considered, such as the relation of the encephalic centres to nutritive or trophic processes; the conditions of the normal activity of the brain; the physiological conditions of consciousness, etc.; but as these questions require discussion in the light more of the phenomena of disease in man, than of experiments on the lower animals, I propose to reserve these and similar topics for another treatise, specially devoted to the consideration of diseases of the brain.




(1), placed on the postero-parietal lobule, indicates the position of the centres for movements of the opposite leg and foot such as are concerned in locomotion.

(2), (3), (4), placed together on the convolutions bounding the upper extremity of the fissure of Rolando, include centres for various complex movements of the arms and legs, such as are concerned in climbing, swimming, etc.

(5), situated at the posterior extremity of the superior frontal convolution, at its junction with the ascending frontal, is the centre for the extension forwards of the arm and hand, as in putting forth the hand to touch something in front.

(6), situated on the ascending frontal, just behind the upper end of the posterior extremity of the middle frontal convolution, is the centre for the movements of the hand and forearm in which the biceps is particularly engaged, *viz.*, supination of the hand and flexion of the forearm.

(7) and (8), centres for the elevators and depressors of the angle of the mouth respectively.

(9) and (10), included together in one, mark the centre for the movements of the lips and tongue, as in articulation. This is the region, disease of which causes aphasia, and is generally known as Broca's convolution.

(11), the centre of the platysma, retraction of the angle of the mouth.

(12), a centre for lateral movements of the head and eyes, with elevation of the eyelids and dilation of pupil.

(*a*), (*b*), (*c*), (*d*), placed on the ascending parietal convolution, indicate the centres of movement of the hand and wrist.

Circles (13) and (13′) placed on the supra-marginal lobule and angular gyrus, indicate the centre of vision.

Circles (14) placed on the superior temporo-sphenoidal convolution, indicate the situation of the centre of hearing.

The centre of smell is situated in the subiculum cornu Ammonis (inner surface of brain).

In close proximity, but not exactly defined as to limits, is the centre of taste.

The centre of touch is situated in the hippocampal region. [But feeling centres seem also to be located in the same regions as the corresponding motor centres.—Ed.]

# SIR WILLIAM CROOKES

Sir William Crookes was born in London in 1832. Since 1851 he has given himself to original research in chemistry. In 1859 he founded the "Chemical News" and in 1864 became editor also of the "Quarterly Journal of Science." He is both a practical and theoretical chemist,—an authority on sewage, beet sugar, dyeing, calico printing; the inventor of the Crookes' tube which led to Röntgen's discoveries; and a theorizer on the ultimate composition of the atom. He is a believer in telepathy, and his deep insight into the laws of radiant energy demands a careful consideration of the hypothesis he explains below.

## TELEPATHY

The task I am called upon to perform to-day is to my thinking by no means a merely formal or easy matter. It fills me with deep concern to give an address, with such authority as a president's chair confers, upon a science which, though still in a purely nascent stage, seems to me at least as important as any other science whatever. Psychical science, as we here try to pursue it, is the embryo of something which in time may dominate the whole world of thought. This possibility—nay, probability—does not make it the easier to me now. Embryonic devel-

opment is apt to be both rapid and interesting; yet the prudent man shrinks from dogmatising on the egg until he has seen the chicken.

Nevertheless, I desire, if I can, to say a helpful word. And I ask myself what kind of helpful word. Is there any connection between my old-standing interest in psychical problems and such original work as I may have been able to do in other branches of science?

I think there is such a connection—that the most helpful quality which has aided me in psychical problems and has made me lucky in physical discoveries (sometimes of rather unexpected kinds) has simply been my knowledge—my vital knowledge, if I may so term it—of my own ignorance.

Most students of nature sooner or later pass through a process of writing off a large percentage of their supposed capital of knowledge as a merely illusory asset. As we trace more accurately certain familiar sequences of phenomena we begin to realize how closely these sequences, or laws, as we call them, are hemmed round by still other laws of which we can form no notion. With myself this writing off of illusory assets has gone rather far and the cobweb of supposed knowledge has been pinched (as some one has phrased) into a particularly small pill.

Telepathy, the transmission of thought and images directly from one mind to another without the agency of the recognized organs of sense, is a conception new and strange to science. To judge from the comparative slowness with which the accumulated evidence of our society penetrates the scientific world, it is, I think, a conception even scientifically repulsive to many minds. We have supplied striking experimental evidence; but few have been found to repeat our experiments. We have offered good evidence in the observation of spontaneous cases, as apparitions at the moment of death and the like, but this evidence has failed to impress the scientific world in the same way as evidence less careful and less coherent has often done before. Our evidence is not confronted and refuted; it is shirked and evaded as though there were some great a priori improbability which absolved the world of science from considering it. I at least see no a priori improbability whatever. Our alleged facts might be true in all kinds of ways without contradicting any truth already known. I will dwell now on only one possible line of explanation, not that I see any way of elucidating all the new phenomena I regard as genuine, but because it seems probable I may shed a light on some of those phenomena.

All the phenomena of the universe are presumably in some way

continuous; and certain facts, plucked as it were from the very heart of nature, are likely to be of use in our gradual discovery of facts which lie deeper still.

Let us, then, consider the vibrations we trace, not only in solid bodies, but in the air, and in a still more remarkable manner in the ether.

These vibrations differ in their velocity and in their frequency. That they exist, extending from one vibration to two thousand millions of millions vibrations per second, we have good evidence. That they subserve the purpose of conveying impressions from outside sources of whatever kind to living organisms may be fully recognized.

As a starting point I will take a pendulum beating seconds in air. If I keep on doubling I will get a series of steps as follows:

| Starting point. | The seconds pendulum. | |
|---|---|---|
| Step 1.... | 2 | vibrations per second. |
| 2.... | 4 | |
| 3.... | 8 | |
| 4.... | 16 | |
| 5.... | 32 | Sound begins to human ear. |
| 6.... | 64 | |
| 7.... | 128 | |
| 8.... | 256 | |
| 9.... | 512 | |
| 10.... | 1024 | |
| 15.... | 32768 | Sound ends to human ear and electrical waves begin. |
| 20.... | 1,048576 | |
| 25.... | 33,554432 | |
| 30.... | 1073,741825 | |
| 35.... | 34359,738368 | Electrical waves end. |
| 40.... | 1,099511,627776 | |
| 45.... | 35,184372,088832 | Light waves begin for human eye. |
| 50.... | 1125,899906,842624 | Light waves end for human eye. |
| 55.... | 36028,707018,963968 | |
| 56.... | 72057,594037,927936 | |
| 57.... | 144115,188075,855872 | |
| 58... | 288220,376151,711744 | X-rays begin? |
| 59.... | 576440,752303,423488 | |
| 60.... | 1,152881,504606,846976 | |
| 61.... | 2,305763,009213,693952 | |
| 62.... | 4,611526,018427,387904 | |
| 63.... | 9,223052,036854,775808 | |

At the fifth step from unity, at 32 vibrations per second, we reach the region where atmospheric vibration reveals itself to us as sound. Here we have the lowest musical note. In the next ten steps the vibrations per second rise from 32 to 32,768, and here, to the average human ear, the region of sound ends. But certain more highly endowed ani-

mals probably hear sounds too acute for our organs; that is, sounds which vibrate at a higher rate.

We next enter a region in which the vibrations rise rapidly, and the vibrating medium is no longer the gross atmosphere, but a highly attenuated medium, "a diviner air," called the ether. From the sixteenth to the thirty-fifth step the vibrations rise from 32,768 to 34359,738368 a second, such vibrations appearing to our means of observation as electrical rays.

We next reach a region extending from the thirty-fifth to the forty-fifth step, including from 34359,738368 to 35,184372,088832 vibrations per second. This region may be considered as unknown, because we are as yet ignorant what are the functions of vibrations of the rates just mentioned. But that they have some function it is fair to suppose.

Now we approach the region of light, the steps extending from the forty-fifth to between the fiftieth and the fifty-first, and the vibrations extending from 35,184372,088832 per second (heat rays) to 1875,000000,000000 per second, the highest recorded rays of the spectrum. The actual sensation of light, and therefore the vibrations which transmit visible signs, being comprised between the narrow limits of about 450,000000,000000 (red light) and 750,000000,000000 (violet light)—less than one step.

Leaving the region of visible light we arrive at what is, for our existing senses and our means of research, another unknown region, the functions of which we are beginning to suspect. It is not unlikely that the X-rays of Professor Röntgen will be found to lie between the fifty-eighth and the sixty-first step, having vibrations extending from 288220,576151,711744 to 2,305763,009213,693952 per second, or even higher.

In this series it will be seen there are two great gaps, or unknown regions, concerning which we must own our entire ignorance as to the part they play in the economy of creation. Further, whether any vibrations exist having a greater number per second than those classes mentioned we do not persume to decide.

But it is premature to ask in what way are vibrations connected with thought or its transmission? We might speculate that the increasing rapidity or frequency of the vibrations would accompany a rise in the importance of the functions of such vibrations. That high frequency deprives the rays of many attributes that might seem incompatible with "brain waves" is undoubted. Thus, rays about the sixty-

second step are so minute as to cease to be refracted, reflected, or polarized; they pass through many so-called opaque bodies, and research begins to show that the most rapid are just those which pass most easily through dense substances. It does not require much stretch of the scientific imagination to conceive that at the sixty-second or sixty-third step the trammels from which rays at the sixty-first step were struggling to free themselves have ceased to influence rays having so enormous a rate of vibration as 9,223052,036854,775808 per second, and that these rays pierce the densest medium with scarcely any diminution of intensity, and pass almost unrefracted and unreflected along their path with the velocity of light.

Ordinarily we communicate intelligence to each other by speech. I first call up in my own brain a picture of a scene I wish to describe, and then, by means of an orderly transmission of wave vibrations set in motion by my vocal chords through the material atmosphere, a corresponding picture is implanted in the brain of anyone whose ear is capable of receiving such vibrations. If the scene I wish to impress on the brain of the recipient is of a complicated character, or if the picture of it in my own brain is not definite, the transmission will be more or less imperfect; but if I wish to get my audience to picture to themselves some very simple object, such as a triangle or a circle, the transmission of ideas will be well-nigh perfect, and equally clear to the brains of both transmitter and recipient. Here we use the vibrations of the material molecules of the atmosphere to transmit intelligence from one brain to another.

In the newly discovered Röntgen rays we are introduced to an order of vibrations of extremest minuteness as compared with the most minute waves with which we have hitherto been acquainted, and of dimensions comparable with the distances between the centers of the atoms of which the material universe is built up; and there is no reason to suppose that we have here reached the limit of frequency. Waves of this character cease to have many of the properties associated with light waves. They are produced in the same ethereal medium, and are probably propagated with the same velocity as light, but here the similarity ends. They cannot be regularly reflected from polished surfaces; they have not been polarized; they are not refracted on passing from one medium to another of different density, and they penetrate considerable thicknesses of substances opaque to light with the same ease with which light passes through glass. It is also demonstrated that these rays, as generated in

the vacuum tube, are not homogeneous, but consist of bundles of different wave-lengths, analogous to what would be differences of color could we see them as light. Some pass easily through flesh, but are partially arrested by bone, while others pass with almost equal facility through bone and flesh.

It seems to me that in these rays we may have a possible mode of transmitting intelligence which, with a few reasonable postulates, may supply a key to much that is obscure in psychical research. Let it be assumed that these rays, or rays even of higher frequency, can pass into the brain and act on some nervous center there. Let it be conceived that the brain contains a center which uses these rays as the vocal chords use sound vibrations (both being under the command of intelligence), and sends them out, with the velocity of light, to impinge on the receiving ganglion of another brain. In this way some, at least, of the phenomena of telepathy, and the transmission of intelligence from one sensitive to another through long distances, seem to come into the domain of law and can be grasped. A sensitive may be one who possesses the telepathic transmitting or receiving ganglion in an advanced state of development, or who, by constant practice, is rendered more sensitive to these high-frequency waves. Experience seems to show that the receiving and the transmitting ganglions are not equally developed; one may be active, while the other, like the pineal eye in man, may be only vestigial. By such an hypothesis no physical laws are violated; neither is it necessary to invoke what is commonly called the supernatural.

To this hypothesis it may be objected that brain waves, like any other waves, must obey physical laws. Therefore, transmission of thought must be easier or more certain the nearer the agent and recipient are to each other, and should die out altogether before great distances are reached. Also it can be urged that if brain waves diffuse in all directions they should affect all sensitives within their radius of action, instead of impressing only one brain. The electric telegraph is not a parallel case, for there a material wire intervenes to conduct and guide the energy to its destination.

These are weighty objections, but not, I think, insurmountable. Far be it from me to say anything disrespectful of the law of inverse squares, but I have already endeavored to show we are dealing with conditions removed from our material and limited conceptions of space, matter, form. Is it inconceivable that intense thought concentrated toward a

sensitive with whom the thinker is in close sympathy may induce a telepathic chain of brain waves, along which the message of thought can go straight to its goal without loss of energy due to distance? And is it also inconceivable that our mundane ideas of space and distance may be superseded in these subtile regions of unsubstantial thought, where "near" and "far" may lose their usual meaning?

I repeat that this speculation is strictly provisional. I dare to suggest it. The time may come when it will be possible to submit it to experimental tests.

I am impelled to one further reflection, dealing with the conservation of energy. We say, with truth, that energy is transformed, but not destroyed, and that whenever we can trace the transformation we find it quantitatively exact. So far as our very rough exactness goes, this is true for inorganic matter and for mechanical forces. But it is only inferentially true for organized matter and for vital forces. We cannot express life in terms of heat or of motion. And thus it happens that just when the exact transformation of energy will be most interesting to watch, we cannot really tell whether any fresh energy has been introduced into the system or not. Let us consider this a little more closely.

It has, of course, always been realized by physicists, and has been especially pointed out by Dr. Croll, that there is a wide difference between the production of motion and the direction of it into a particular channel. The production of motion, molar or molecular, is governed by physical laws, which it is the business of the philosopher to find out and correlate. The law of the conservation of energy overrides all laws, and it is a pre-eminent canon of scientific belief that for every act done a corresponding expenditure of energy must be transformed. No work can be effected without using up a corresponding value in energy of another kind. But to us the other side of the problem is even of more importance. Granted the existence of a certain kind of molecular motion, what is it that determines its direction along one path rather than another? A weight falls to the earth through a distance of 3 feet. I lift it, and let it fall once more. In these movements of the weight a certain amount of energy is expended in its rise and the same amount is liberated in its fall. But instead of letting the weight fall free, suppose I harness it to a complicated system of wheels, and, instead of letting the weight fall in the fraction of a second, I distribute its fall over twenty-four hours. No more energy is expended in raising the weight,

and in its slow fall no more or less energy is developed than when it fell free; but I have made it do work of another kind. It now drives a clock, a telescope, or a philosophic instrument, and does what we call useful work. The clock runs down. I lift the weight by exerting the proper amount of energy, and in this action the law of conservation of energy is strictly obeyed. But now I have the choice of either letting the weight fall free in a fraction of a second, or, constrained by the wheel-work, in twenty-four hours. I can do which I like, and whichever way I decide, no more energy is developed in the fall of the weight. I strike a match; I can use it to light a cigarette or to set fire to a house. I write a telegram; it may be simply to say I shall be late for dinner, or it may produce fluctuations on the stock exchange that will ruin thousands. In these cases the actual force required in striking the match or in writing the telegram is governed by the law or conservation of energy; but the vastly more momentous part, which determines the words I use or the material I ignite, is beyond such a law. It is probable that no expenditure of energy need be used in the determination of direction one way more than another. Intelligence and free will here come into play, and these mystic forces are outside the law of conservation of energy as understood by physicists.

The whole universe, as we see it, is the result of molecular movement. Molecular movements strictly obey the law of conservation of energy, but what we call "law" is simply an expression of the direction along which a form of energy acts, not the form of energy itself. We may explain molecular and molar motions, and discover all the physical laws of motion, but we shall be as far as ever from a solution of the vastly more important question as to what form of will and intellect is behind the motions of molecules, guiding and constraining them in definite directions along predetermined paths. What is the determining cause in the background? What combination of will and intellect outside our physical laws guides the fortuitous concourse of atoms along ordered paths culminating in the material world in which we live?

In these last sentences I have intentionally used words of wide signification—have spoken of guidance along ordered paths. It is wisdom to be vague here, for we absolutely cannot say whether or when any diversion may be introduced into the existing system of earthly forces by an external power. We can no more be certain that this is not so than I can be certain, in an express train, that no signalman has pressed a handle to direct the train onto this or that line of rails. I may compute

exactly how much coal is used per mile, so as to be able to say at any minute how many miles we have traveled, but, unless I actually see the points, I cannot tell whether they are shifted before the train passes.

An omnipotent being could rule the course of this world in such a way that none of us should discover the hidden springs of action. He need not make the sun stand still upon Gibeon. He could do all that he wanted by the expenditure of infinitesimal diverting force upon ultra-microscopic modifications of the human germ.

In this address I have not attempted to add any item to the sound knowledge which I believe our society is gradually amassing. I shall be content if I have helped to clear away some of those scientific stumbling-blocks, if I may so call them, which tend to prevent many of our possible coadjutors from adventuring themselves on the new illimitable road.

I see no good reason why any man of scientific mind should shut his eyes to our work or deliberately stand aloof from it. Our proceedings are, of course, not exactly parallel to the proceedings of a society dealing with a long-established branch of science. In every form of research there must be a beginning. We own to much that is tentative, much that may turn out erroneous. But it is thus, and thus only, that each science in turn takes its stand. I venture to assert that both in actual careful record of new and important facts, and in suggestiveness, our society's work and publications will form no unworthy preface to a profounder science both of man, of nature, and of "worlds not realised" than this planet has yet known.

# CHRONOLOGICAL INDEX

| RELIGION | PHILOSOPHY | SOCIAL SCIENCES Including Economics, Political Science, Institutions, Laws, Education, etc. | NATURAL SCIENCES |
|---|---|---|---|
| | **ERA OF ASSYRIA—BABYLONIA. 4000 B. C.** | | |
| Babylonian Account of Creation, I, 9.<br>The Chaldean Flood Story, I, 16.<br>Legend of Sargon, 3800 B. C., I, 21.<br>Ishtar's Descent into Hades, I, 22.<br>Penitential Psalms, I, 25. | | Invented cuneiform writing on clay tablets. | Named the 12 signs of the zodiac. Discovered the cycle of 223 lunar months in which eclipses recur in regular order. |
| | | Babylonian Laws, I, 27. | Knew about squares and cubes of numbers from 1-60. |
| | | Recent archæological discoveries in Babylonian society in vol. X. | Built in brick. |
| | **ERA OF EGYPT. 3000 B. C.** | | |
| Worship of Osiris in Book of the Dead, I, 29, illustrating the Egyptian belief in the life after death, the intense materiality of that life, the power of assuming various forms, the judgment of the dead, rules of life, etc. | | Invented heiroglyphic writing. | Mensuration and art of building shown in the pyramids. |
| Hymn to the Nile, I, 75. | | Egyptian life described by Herodotus (400 B. C.), I, 80-108. | Marked the length of the year. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | ERA OF THE JEWS. | | |
| See Genesis, the Psalms, and the Prophets. | See Proverbs, Job, Ecclesiastes, Book of Jesus, Son of Sirach. | See Exodus, Leviticus, Numbers, Deuteronomy. | |
| | ERA OF THE BRAHMANS. | | |
| Vedic Hymns, showing the early personification and worship of the forces of nature:<br>To the Unknown God, I, 109.<br>To Vata (The Wind), I, 110.<br>To Agni (Fire), and the Maruts (Storm Gods), I, 110.<br>To the Maruts, I, 111.<br>To the Maruts, I, 112.<br>To Rudra (Lightning), I, 113.<br>To Vayu (The Wind), I, 114.<br>To Agni and the Maruts, I, 114.<br>To Rudra, I, 115. | | | |
| The Upanishads, showing the later philosophical development of the religion. The Brahmans gradually reduced the many gods of nature to one, and identified that one in nature with the self of the individual. This knowledge was made essential to salvation and jealously guarded by the caste.<br>Katha Upanishad, the secret disclosed by Death to Nakiketas, I, 116-126. | The idea of the identity of the universe with the self, I, 126, 154-160, 185, 194, 217, etc.<br>See the Upanishads throughout. | Laws and life of the castes, I, 201-208.<br>Education, I, 127—, 162—, 185—. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| Brihadaranyaka Upanishad, the gradual unfolding of the Brahman belief by Yagnavalkya, I, 127-161.<br>Khandogya Upanishad, other unfoldings of the secret, etc., I, 162-195.<br>The Creation, I, 195.<br>The Ages, I, 200.<br>Transmigration of souls and rewards and punishments, I, 208-217. | | | |
| | ERA OF PERSIA. | | |
| Zoroaster (somewhere between the fifteenth and tenth century B. C.)<br>The Gathas—the Good and Evil Principles, I, 354-381. | | | |
| | ERA OF CHINA. | | |
| Confucius (551-478 B. C.), I, 382-411.<br>More ethical than religious. | Rules of life, I, 382-411. | Many of the customs and rules of propriety of China to-day date back to Confucius, I, 382-411. | |
| | ERA OF BUDDHA. | | |
| Buddha (Fifth century B. C.), objected to the caste system of the Brahmans, and made a better life hereafter depend | All of Buddha's sermons are ethical in their nature.<br>The "eight-fold path," I, 220. | Rules of conduct, I, 233-245.<br>Customs of Buddha, I, 253-322.<br>Proverbs, I, 323-353. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| on right conduct and purposes rather than merely on knowledge. He still retained the Brahman idea of an impersonal God (Brahma) and the transmigration of souls.<br>Foundation of the Kingdom of Righteousness, containing the "eight-fold path," I, 220-224.<br>On Knowledge of the Vedas, against the Brahmans, I, 225-245.<br>All the Asavas, the ideas that should be cherished or abandoned, the rules of conduct, against the soul, etc., I, 245-253.<br>The Last Days of Buddha, the Life of Buddha, the Buddhist Gospel, I, 253-321.<br>Dhammapada, the choicest Buddhist thoughts and sayings, I, 322-353. | | | |

## ERA OF GREECE.

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| Hesiod, II, 3-34.<br>The Creation, II, 4.<br>Genesis of the Gods, II, 6-26.<br>Conquest of Uranus by Cronos, II, 7.<br>Conquest of Cronos by Zeus, II, 12. | The first step in Greek philosophy was made by asking what is the permanent, unchanging reality behind the shifting changes of nature. The early philosophers touch on many things, but this question runs through them all.<br>Thales (about 585 B. C., thought this | Life and institutions of the Spartans, II, 105-135. Spartan education.<br>Life and institutions of the Athenians, II, 54-105.<br>Draco (621 B. C.), II, 56.<br>Solon (594 B. C.), II, 57-63. Laws. | The Greeks made many brilliant scientific *guesses*, but without *proof*, the true could not be told from the false.<br>Thales knew something about mensuration. Foretold eclipses |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| The theft of fire for man by Prometheus, II, 15, 27.<br>Woman (Pandora) and the entrance of evil, II, 16, 27. | source of all things to be *water*, II, 138-140. | Sociological poems — extant parts. | by means of the Babylonian cycle of 223 lunar months. Marked solstices and equinoxes. |
| Subjection of the Titans, II, 17.<br>The Four Ages, II, 28.<br>Rules of life, II, 32.<br>Ideas of the Future Life.<br>Descent of Odysseus into Hades, and his description of Hades, II, 35-49. | Anaximander (610 B. C.—after 546 B. C.) thought there was an *infinite but indeterminate substance* back of things which produced things by separating into its opposites. He thought man came from other animals in the beginning, arguing from the length and helplessness of human infancy, II, 140-143. | Peisistratus (560 B. C.), II, 63-67. | Anaximander thought the heavenly bodies wheels of fire. Rain moisture drawn up by the sun. Living creatures first came to exist in the sea. Man evolved from lower animals, shown by the weakness and length of his infancy. The earth cylindrical. II, 140-143. Made map of the world and sun-dials. |
| Elysium, II, 49-52.<br>The mysteries, II, 52. | Anaximenes (latter half of 6th century B. C.) thought the world substance to be *infinite*, but *air*, II, 143-145. | | Anaximenes thought all things came from air. |
| Pythagoras founded a religious order that for a time held the political power in Croton. | Pythagoras (about 570 B. C. ? ). Most of the legends about Pythagoras are mythical; the sayings that seem most surely to go back to him are like the taboos of a "medicine man," II, 145, 146. | | |
| Greek anthropomorphism satirized by Xenophanes. | Xenophanes (about 571 B. C.—after 479 B. C.) believed the universe to be *one unchangeable God*, and satirized the Greek idea of many human-like gods. | Hippias and Hipparchus (527-510 B. C.), II, 67-69. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | II, 146-148. All things from earth and water. | Cleisthenes (508 B. C.), II, 69-72. | |
| | Herakleitos (around 500 B. C.), thought the characteristic of the world-substance to be *a continual flux* from opposite to opposite, and *the source of all things to be fire*, II, 148-156. | | |
| | Parmenides 515 B. C.—440 B. C. ? ) believed the universe to be without beginning or end in time, immovable and unchangeable. Hence in his developing the idea of the unity of the universe to its limit, he denied any real change at all, II, 156-160. | | |
| Transmigration of souls believed in by Empedokles. | Empedokles (first half of 5th century B. C.) tried to combine these theories. He sought to find in water, air, fire, and earth, the four elements of things, with love and hate as the causes of motion, II, 160-175. | | Empedokles: the structure of the pores, II, 168. The senses, II, 174. Trees the first living things, II, 173. |
| | Anaxagoras (1st half of 5th century B. C.) thought there are as many elements as there are qualities, with Mind ruling all the mixture, II, 175-180. | | Anaxagoras thought the earth flat, the sun a stone the size of the Pelopennesus. The moon gets her light from the sun. Planets move. Cause of eclipses, the intervention of the earth or moon. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | Zeno (489 B. C.— ? ) reinforced the idea of the unity of the universe held by Parmenides, by showing the difficulties involved in the idea of many elements and plurality, II, 180-182. | | |
| | Melissos, the general of Samnos, victor over the Athenian fleet in 440 B. C., argued for the unreality of our perceptions and the paradoxical unity of all things, II, 182-185. | | |
| | The Pythagoreans thought the constant number relations were the true reality of the universe, II, 185. | | The Pythagoreans thought the earth round and to go around the sun. |
| Protagoras was banished for doubting the existence of the Gods. | Protagoras (480 B. C.— ? ) thought all knowledge is merely a question of personal opinion, and hence true science impossible, II, 186, 201—. | Pericles (460-429 B. C.), II, 75—. | |
| | Leukippos and Demokritos (460 ? B. C.—360 ? B. C.) developed the idea of the atom and of the universe being developed from the accidental rushing together of purposeless atoms, II, 187. | | Leukippos and Demokritos. The atomic theory, II, 187. |
| Socrates was executed for introducing strange gods. On immortality, II, 249-311. | Socrates (470 B. C.—399 B. C.) began, with the Sophists, to turn philosophy to the discussion of life and happiness. He believed that happiness would be brought by virtue, virtue secured by knowledge, and that things may be | | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | grouped into classes and defined, and a general statement made of the class that will hold good. Hence the goal of science would be classification and definition, II, 187, 191-239. | | |
| Plato.<br>The Phaido, II, 249-311. | Plato (429 B. C.—348 B. C.).<br>The possibility of science, II, 191-239.<br>The doctrine of Ideas, II, 239-249.<br>The Ideas as final causes, and the question of immortality, II, 249-311.<br>The philosophy of the state, II, 311-338.<br>Diogenes the Cynic (412 B. C.—323 ? B. C.) believed the greatest good to be freedom from wants; hence he rebelled against all civilization, II, 339-343. | Plato began political science.<br>Origin of the State, II, 311-320.<br>Education by the State, II, 320-328.<br>Community in the State, II, 328-338. | Hippocrates (420- ? ), III, 286-288. Showed that diseases come not from the anger of the gods, as formerly thought, but from natural causes.<br>Eudoxus (406- ? ).<br>studied the movements and return of the planets, III, 288. |
| Aristotle.<br>Proof of God's existence, II, 352-363.<br>Basis of Ethics, II, 364, 382. | Aristotle (384-322 B. C.).<br>The relation of the general to the particular (logic), II, 350.<br>The interrelations of things (the categories), II, 345-350.<br>The examination into existence, culminating in the proof of God, II, 352-363.<br>The basis of ethics; happiness, the greatest good, is the result of the activity of the soul in accordance with its greatest excellence; virtues, habits; the law of the middle path, II, 364-382. | Aristotle.<br>Origin of the State, II, 383-386.<br>The Ideal State, II, 386-418.<br>Education in the State, II, 411-418.<br>History and description of the Athenian constitution, II, 54-105. | Aristotle.<br>Made great zoological collections. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | Philosophy of the state, II, 383-418.<br>Developed Rhetoric.<br>Zeno the Stoic (350 ? B. C.—258 ? B. C.) thought the chief good to be a virtue that by calm submission to natural law, by doing one's duty, rose superior to pleasure, trouble, desire, or fear, II, 418-425.<br>Epicurus (341 ? B. C.—270 B. C.).<br>The chief good the highest form of pleasure, II, 426-430. | | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | | ERA OF ROME. | |
| The Roman religion was closely related to the Greek, and was later identified by the Romans with the Greek. As in the case of the Brahmans and Greeks, their gods originally represented natural forces. They developed but few myths about them, but later adopted the Greek. Peculiar Roman religious institutions were the household gods called the *lares*, the judging the wills of the gods through auspices, etc. | | Appian's review of the Roman contentions, III, 5.<br>Origin of Roman law, III, 9.—Justinian's Digest.<br>The Quaestor (before 509 B. C.), III, 52.<br>The right of appeal to the people in capital cases, 509 B. C., III, 12.—Cicero.<br>The Tribunes, 494 B. C., III, 3, 30.<br>The Decemvirs, 451-449 B. C., III, 13—, 15—.<br>Fragments of the Twelve Tables, 449 B. C., III, 9—.<br>Laws passed by the people assembled in tribes to be binding on all, 449 B. C.—Dionysius Halicarnassus, III. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | | Renewal of the sacredness of the Tribunes, 449 B. C., III, 16.<br>Right of intermarriage—the Canuleian Law—B. C. 445, III, 17-25.<br>The Military Tribunes, 444 B. C., III, 24.<br>The Censors established, 443 B. C., III, 34.<br>A regular army established, the troops paid, and winter campaigns begun, 406-400 B. C., III, 25-30. | |
| | | The Praetorship, 367 B. C., III, 46.<br>The Licinian Law, 361 B. C., compromising the land question; one consul a pleb; interest deducted from the principal of debts; slave labor, and amount of land held limited, III, 35-46.<br>All offices thrown open to the plebeians by the Publilian laws, 336 B. C. Orders of commons binding on all. III, 47. | |
| | | The censorship, 312 B. C.; also public road building by Appius Claudius.<br>Priesthood opened to plebeians, 300 B. C., III., 48.<br>Hortensian Law, 287 B. C., made all laws passed by the plebs alone binding on all. III, 53.—Aulus Gellius.<br>Annexation of Sabine territory, 290 B. C.<br>War with Pyrrhus and Tarentum. All Italy made part of the growing empire, 272 B. C. | Appian road, 312 B. C., the beginning of public road building, etc.<br>Graeco-Roman Science.<br>Aristarchus (3rd century B. C.) held the Copernican theory that the earth revolves on its own axis and about the sun, III. 288. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | | First Punic War, 264-241 B. C. | Euclid (300 B. C. ? ) founded geometry, III, 288. |
| | | Second Punic War, 218-201 B. C. Spain acquired. | Archimedes (287-212 B. C.), discovered the principle of the lever, specific gravity, the water-screw, etc., thus founding mechanics, III, 288-290. |
| | | Second Macedonian War, 200-196 B. C. Greece "liberated." | |
| | | The Bacchanalian revelers repressed, 186 B. C., III, 65-77. | |
| | | Third Macedonian War. 172-168 B. C. Macedonia divided. | |
| | | Destruction of Carthage, 146 B. C. | Erastosthenes (276- ? B. C.) measured the circumference of the earth, III, 290. |
| | | Destruction of Corinth, 146 B. C. | |
| | | Strictures on dress and food, 145 B. C., III, 54-65. | Hipparchus (160- ? B. C.) catalogued the stars, III, 290. Noted the precession of the equinoxes. |
| | | The Gracchi, 133-121 B. C., III, 77-90. | |
| | | Mismanagement of the provinces, III, 77-90. | |
| | | Rome after the Punic Wars, by Polybius. An analysis of the Roman government, military institutions, etc., III, 166-193. Rome and Carthage compared. | |
| | | Transalpine Gaul made a province, 120 B. C. | |
| | | The Social War, 90-89 B. C. Allies admitted to citizenship, III, 90, 91. | |
| | | Marius and Sulla, 88-79 B. C. | |
| Cicero on immortality, III, 238-262. | Cicero. Scipio's Dream, III, 233-241. | Cicero (105-43 B. C.), III, 215-262. The Principles of Law, III, 216-228. The Best Forms of Government, III, 228-238. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | The Contempt of Death, III, 241-262.<br>Lucretius. The atomic theory. | The First Triumvirate, 60 B. C.<br>Civil War between Caesar and Pompey, 49 B. C.<br>The Second Triumvirate, 43 B. C.<br>Growth of luxury at the close of the republic, III, 193.—Lucan.<br>The empire established under the guise of a republic, 27 B. C., III, 92.—Dio Cassius.<br>Elections taken from the people and given to the senate, 14 A. D., III, 92. | Lucretius (98-55 B. C.), the atomic theory, III, 262-275. |
| | Philo Judaeus (20 B. C. —40 A. D.).<br>Neo-Platonism.<br>The Creation of the World.<br>Pre-Christian Ascetics, III, 355-369.<br>Seneca (4 B. C.—65 A. D.)<br>The Stoic philosophy of Peace of Mind, III, 328-354. | Luxury increased from the time of Actium (31 B. C.) to Tiberius; then began to decline among the senators though the extravagance of the emperors increased through the time of Nero (54 A. D.); and with Vespasian a period of parsimonious living began, lasting about 100 years. III, 194—. | Pliny the Elder (23-79 A. D.).<br>The Scientific Ideas of the Time, III, 294.<br>The Inventors of Various Things, III, 305-310. |
| | | Growth of royal power under Vespasian, 69 A. D., III, 93.<br>Quintilian (35-95 A. D.), The Ideal Education, III, 312-326. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | | Nerva, care of indigent children 96-97 A. D. III, 94. | |
| Pliny, Trajan and Hadrian on the Christians, IV, 7. | Epictetus ( ? -117 A. D.) Stoic. Philosopher. Discourses, III, 392-407. | Trajan, 98 A. D. The empire at its widest extent. The paternalism of the empire, IV, 7. Plutarch (50 A. D.-120 A. D.). The training of children III, 370-391. | Ptolemy (70-150 A. D.) Theory of the heavens, III, 290. |
| Persecution under Marcus Aurelius, A. D. 177. IV, 9. | Aurelius. "Thoughts"—the Stoic Philosophy, III, 406 | Marcus Aurelius, 161 A. D., IV, 9. | Galen (131 A. D.—?) vastly increased the knowledge of the body, III, 291. Distinguished and studied veins and arteries, VI, 9. |
| Tertullian (150—220-240). The Witness of the Soul, IV, 21-28. Origen (186-258). Principles of Faith, IV, 29-35. Cyprian (200-254). The Unity of the Church, IV, 35-51. Persecution under Valerian (254), IV, 13. | | Caracalla extends citizenship to all inhabitants of the empire (212 A. D.) in order to include all in certain taxation, III, 95. | |
| Persecution of Diocletian, IV, 14. Edict of Toleration by Galerius, 303 A. D., IV, 17. Synod of Elvira, IV, 111. The problems of the church. Decree of Milan, 313 A. D., IV, 19. Origin of Asceticism, IV, 51-62. | | Diocletian (284 A. D.). An absolute monarchy, III, 95-99. | |
| St. Athanasius (298-373). Exposition of the Faith, IV, 71. Nicaene Creed (325 A. D.), IV, 122. | | Constantine the Great founds Constantinople (328 A. D.). Marcellinus: Fourth Century Roman Life, III, 202. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| Athanasian Creed.<br>Suppression of heathenism and heresy, IV, 62-71.<br>St. Ambrose to Valentinian, IV, 62.<br>Enactments from the Theodosian code, IV, 69.<br>St. Augustine (354-430). God's Foreknowledge and Man's Free Will, IV, 75.<br>Original Sin, IV, 90.<br>Redemption, IV, 97.<br>Faith, Hope and Love, IV, 102.<br>Leo I, and the Petrine Theory of the Papacy, (440-461), IV, 125. | | Theodosius, 378-395 A. D.<br>The customs of the Germans by Tacitus, IV, 165.<br>The Conquest of Britain, by Bede, 449-456 A. D., IV, 188.<br>Overthrow of Empire, 475 A. D. | |

MIDDLE AGES.

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| Conversion of the Franks, 496 A. D., IV, 202, by Gregory of Tours.<br>Conversion of Kent, 596 A. D., IV, 190 (by Bede).<br>Conversion of East Angles, 627 A. D., (by Bede), IV, 194.<br>Monasticism, IV. 128-165, by St Benedict. Customs and Rules.<br>Victory of the Roman Church in Britain, 652 A. D., IV, 196 (by Bede).<br>Mohammed (570-632).<br>The Koran, IV, 241-277.<br>About this period began the Era of the Arabs in Religion.<br>Donation of Pippin, 756 A. D., IV, 203. | | The Salic Law, the laws of the Franks, IV, 177-188.<br>Justinian, Eastern Emperor, codifies existing Roman laws, 527-565.<br>The Institutes of Justinian, the body of Roman law, III, 100-166.<br>The laws of the Anglo-Saxons, of King Aethelbirht of Kent (560-616), of Hlothhaere and Eadric (673-686), of Withraed (690-725), of Alfred (871-924), Edward (901-924), with Guthrum the Dane, of Aethelstan (924- ? ), Edmund and Edgar, IV, 211-240. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| Donation of Karl the Great, 774 A. D., IV, 204. | | Coronation of Karl the Great, 800 A. D., IV, 205.<br>School of Karl the Great, IV, 206.<br>Treaty of Verdün, 843 A. D., the divisions of modern Europe formed. | Geber (Djafer) (830 ? - ? ).<br>Alchemist; made nitric and sulphuric acid, IV, 278. |
| | Avicenna (Ibn Sina), (980-1037) doctor, and neo-Platonist, IV, 279.<br>Eternity of universe and identity of universal intelligence in man.<br>Avicebron (1028-1058), poet and neo-Platonist. The Will of God the final cause of the world, IV, 280.<br>Averroes (1126-1198), commentator of Aristotle, IV, 281.<br>Moses Maimonides (1135-1204) attempted to combine Jewish theology and Aristotle, IV, 281.<br>Method of proving God's existence, IV, 282-284. | Feudalism. The disintegration of Europe left the barons each to govern his own county with but slight dependence on the higher duke or king.<br>Forms of dependence of the serfs and freemen, IV, 300.<br>Private jurisdictions, IV, 301.<br>Homage and fealty, IV, 303.<br>Mutual duties, IV, 306.<br>Authority of the lord, IV, 307.<br>Compurgation, IV, 308.<br>Ordeals, IV, 309.<br>Wagers of battle, IV, 315.<br>The Struggle between Church and State, IV, 318. | Albategnuis (879?-?) calculated the length of year with great exactness, IV, 278.<br>Ben Musa (900 ?-?) introduced algebra and Indian numerals; afterwards brought into Europe by Gerbert, Pope Sylvester II, IV, 278.<br>Alhazen (1000?-?). Optics, refraction of light, used convex lenses, IV, 279. |
| Gregory VII., 1073-1085, IV, 320.<br>Claims of the Pope.<br>Declarations of the Church, simony, lay investiture, celibacy, annual confession, transubstantiation, IV, 323. | A Parallel between the Universe and Man, IV, 284-293. | Program of Gregory VII. (1073-1085), IV, 320. Claims of the pope.<br>Declarations of the Church on lay investiture, celibacy, simony, annual confession, transubstantiation, IV, 321. | |
| Gregory VII. vs. Henry IV., IV, 323. | Propositions admitted, IV, 293-299. | Gregory VII. vs. Henry IV., IV, 323. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| The Crusades, IV, 335-350.<br>William of Tyre on Peter the Hermit<br>Urban II, Speech at Clermont, 1095.<br>The Truce of God.<br>Privileges of the Crusaders.<br>Account of the Start. | | Mediaeval Universities, IV, 350.<br>Privileges, Frederick I., 1158 A. D.<br>Gregory IX., for the University of Paris, 1231 A. D.<br>Course of Study, Robert de Courcon, 1215 A. D.<br>Life of Students. | |
| | St. Thomas Aquinas, 1225 ? - 1274 A. D. The philosophy of the Church. Scholasticism on the existence of God, IV, 359.<br>Theory of knowledge, IV, 363. | Saxons and Normans, by William of Malmesbury, IV, 384.<br>Rise of the Cities, IV, 390-397.<br>English city customs.<br>Typical charters.<br>A typical guild.<br>Norman Judicial Customs, 1166 A. D., IV, 397. | Roger Bacon (1214-1292).<br>On Experimental Science, IV, 369. |
| John Wycliffe (1320 ? -1384).<br>Conclusions, IV, 378.<br>Wycliffe and Pope Gregory XI., IV, 380-383. | | The Magna Carta, 1215 A. D., IV, 401.<br>Uprising under Ball and Tyler, by Froissart, IV, 413.<br>Marsilius of Padua (latter half 13th century). The beginning of the modern theory of the state, IV, 423. | |
| | | The revival of interest in classical learning. Petrach (1304-1374). | Flavio Giopa (1300 ? - ?). Invented mariner's compass. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | | MODERN ERA. | |
| | | Fall of Constantinople (1453) and diffusion of Greek knowledge in Western Europe, V, 5. | Guttenburg invents printing, 1438, V, 5. |
| | | | Columbus discovers America (1492). Journal of his first voyage, V, 7-26.<br>Vasco a Gama rounds Africa to India (1498), V, 26-41. |
| | | Machiavelli (1469-1527).<br>Mediaeval and early modern political ideas.<br>The Prince, V, 58-95. | |
| | | | Magellan rounds world (1519-1522). Account by Genoese pilot, V, 41-58. These geographical discoveries settled the question of the rotundity of the earth. |
| | | | Copernicus (1473-1543), argued that the earth goes round the sun. Though the knowledge of the time was not sufficient to *prove* this, yet the theory steadily grew.<br>The Copernican Theory, V, 96-101. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| The Reformation, V, 102.<br>Erasmus (1466 ? -1536), V, 103-110.<br>Translated the New Testament.<br>Satirized the foibles of the church and clergy.<br>Benefice-Hunting.<br>The Penitent Virgin. | | | |
| Martin Luther (1483-1556), V, 111-134.<br>Ninety-five Theses, V, 112.<br>Against Catholicism, V, 119.<br>Justification by Faith, V, 127. | | | Paracelsus (1493- ? ).<br>Alchemist, but turns alchemy to aid of health. Introduced antimony. |
| The Peasant Revolt (1525), V, 134.<br>The Twelve Articles (Demands) of the Peasants, V, 135. | | Peasant Revolt in Germany, (1525), V, 134. | |
| John Calvin (1509-1564), V, 140.<br>Doctrine of eternal election, V, 141-150. | | Cortez: Account of the Aztec Civilization in 1520, V, 317-326. | |
| The whole case of the Protestants as given to the world in the Augsburg Confession (1530), V, 151-179.<br>Loyola (1491-1556), V, 179.<br>The Jesuit Constitution, V, 180-188.<br>Revolt of the Protestant Netherlands, 1566-1609, V, 189. | Giordano Bruno (1550 ? - 1600).<br>Mystic. Believed the universe a great animal. Burned at the stake in 1600 for openly teaching the Copernican system. | Mendoza: Founding of St. Augustine (1565), V, 327-341.<br>Dutch Case in their Declaration of Independence, V, 189-198. | Vesalius (1536?-1564). VI, 5.<br>Corrected Galenic ideas of anatomy by observation of the human skeleton itself. Held the ancient belief that arteries contain vital spirits.<br>Baptiste Porta (1545- ? ). Invents the camera obscura.<br>Dr. Gilbert (1540-1603). Made the first few experiments on electricity. Found that certain substances attract when rubbed. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | Francis Bacon (1561-1626). The philosophical doctrine of experiment.<br>The Novum Organum, V, 234-289. | Montaigne (1533-1592), V, 198.<br>On the Education of Children, V, 190-232.<br>Jamestown founded (1607).<br>Quebec: account by Champlain (1608), V, 342-354.<br>Morton: Customs of the Indians in 1637, V, 360-376.<br>The First Written Constitution, Connecticut (1638), V, 354-360.<br>Hooker: Church Questions in New England, V, 378.<br>The English Revolution (1628-1649), V, 391.<br>The Petition of Right (1628), V, 393.<br>First Writ of Ship-Money, Specimen, (1635), V, 396.<br>Pym against Strafford (1641), V, 399.<br>The case of parliament in the Grand Remonstrance (1641), 403-430.<br>Ratke (1571-?): Educational rules, VI, 24.<br>Comenius (1592-1670).<br>Educational Ideas, VI, 25-38. | Fabricius ( ? - ? ) discovered valves in veins. This led later to Harvey's discovery, VI, 7.<br>Francis Bacon (1561-1626). All science based on experiment.<br>The Novum Organum, V, 234-289.<br>Galileo (1564-1642), V, 290-308.<br>Laws of motion.<br>Thermometer invented.<br>Discovered mountains of moon, the moons of Jupiter, and the phases of Venus.<br>For the Copernican System, V, 292-302.<br>Condemnation by Inquisition, V, 302-306.<br>Recantation, V, 306-307.<br>Tycho Brahe (1546-1601). Compiled the Rudolphian Tables, V, 308.<br>Kepler (1571-1630), V, 308-315.<br>Planets move in elipses, V, 309.<br>Areas swept over in equal times are equal, V, 309.<br>Cubes of distances proportional to the squares of the times, V, 310.<br>The Principles of Astronomy, V, 311-315.<br>Harvey (1577-1657).<br>The circulation of the blood discovered, VI, 5. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | Descartes (1596-1650), VI, 41.<br>Meditations, VI, 42-63.<br>The new starting point for philosophy. Principle of certainty; "Cogito, ergo, sum;" dualism between matter and mind. | Jean Bodin (latter half of 16th century).<br>Explained the ten-fold rise in prices by the importation of gold from the New World, VI, 155.<br>The prevailing political economy was the mercantile system which strove for the balance of trade and discouraged imports.<br>Thomas Mun (1571-1641), VI, 157-163.<br>The mercantile theory.<br>Other representatives of the mercantile school, VI, 155-157. | Asellius discovers the lacteal circulation 1622. VI, 117.<br>Torricelli invented the barometer (1644), VI, 117. |
| | Geulincx (1625-1669), VI, 38.<br>Matter and mind run in harmony as do two clocks, because both controlled by their maker.<br>Malebranche (1638-1715).<br>"We see all things through God." VI, 38-39.<br>Spinoza (1632-1677), VI, 63-78.<br>Transformed Descartes dualism into a monism. God the only substance, all else manifestations. | Sir William Petty (1623-1687), a precursor of the new school.<br>Value depends on labor, VI, 156. | Olaüs Rüdbeck found that the lymphatics furnished the heart with material for new blood (1649), VI, 117.<br>Guericke invented the air-pump (1650), VI, 118.<br>Pascal proved that it is the weight of the air that causes the rise of the mercury, (1656), VI, 118.<br>Malpighi and Grew discovered the air cells in the lungs, the capillary cells, the cells in plants, etc., VI, 118. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | John Locke (1632-1704), VI, 101-116.<br>All ideas from sensation and reflection. No innate ideas or unconscious thought, VI, 39, 101-116.<br>Things and the soul are taken for granted by us as a ground of our ideas. As clear an idea of spirit as of matter. | The Bill of Rights (1689), VII, 15-16.<br>Locke (1632-1704.<br>The Basis of Property is Labor, VI, 164-171.<br>The Origin of Political Societies and the Right of the People to Revolt, VII, 25-35. | ıthony von Leeuwenhoeck (1632-1723), VI, 119-123. Discovered the red corpuscles in the blood; the animalculae in water; the capillary circulation. Also an investigator of insects.<br>ericke invented first electrical machine (1676), VI, 118.<br>ibnitz invented differential calculus, VI, 79.<br>wton (1642-1727), VI, 123-141.<br>nvented method of fluxions, VI, 123.<br>The Composition of Light, VI, 124-134.<br>The Theory of Gravitation, VI, 135-141.<br>Applied the theory to explain the tides, etc. (1682).<br>emer estimated the velocity of light to be 190,000 miles a second (1676). Proof, VI, 118, 146-148.<br>Huyghens (1609-1695), VI, 141-150).<br>Discovered the rings and the sixth satellite of Saturn (1655).<br>Invented the pendulum clock (1657).<br>The Wave Theory of Light (1690), VI, 142-150.<br>The beginning of chemistry, VI, 150-151.<br>Robert Boyle (1627-1691), VI, 152-154.<br>Law of the compressibility of gases.<br>Stahl (1660-1734). The phlogiston theory that combustion is the driving off of a "fire-element", VI, 151. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | Berkeley (1685-1753).<br>Idealism, VI, 172.<br>Principles of Human Knowledge, VI, 173-184. | Montesquieu (1689-1755), VII, 35-46.<br>The principle of the separation of powers. | Boerhaave (1668, Dec. 31—1738), VI, 242-247.<br>Studied the absorption by plants of substances from the soil, VI, 240, 242.<br>Physiological conceptions, VI, 242-247. |
| Wesley (1703-1791), VI, 362-377.<br>The Early Methodists (1739).<br>General Rules.<br>Doctrine of Justification.<br>Voltaire (1694-1778). Struggled against intolerance in religion and government.<br>On Toleration, VI, 377-391. | | The physiocratic school of political economy, led by Gournay and Quesnay.<br>Quesnay (1694-1774), VI, 392-399. General Maxims. | Linnaeus (1707-1778), VI, 247-261.<br>New system in botany.<br>The sex system in plants, VI, 248-261.<br><br>Franklin (1706-1790), VI, 261-272.<br>Electrical experiments. Positive and negative electricity, VI, 262-266.<br>The identity of electricity and lightning. The lightning rod, VI, 266-269. (1747).<br>The kite experiment, VI, 270-272. |
| | Hume (1711-1776).<br>Scepticism, Economic ideas, VI, 185.<br>Against the Principle of Cause and Effect, VI, 185.<br>Against Personal Identity, VI, 189.<br><br>Kant (1724-1804).<br>The matter of knowledge | Rousseau (1712-1778).<br>The "Contrat Social" (1762): The ruler only the instrument of the people, who are always sovereign, VII, 47-55.<br>Stands for naturalness in education, VII, 46, IX.<br><br>English Colonial System, VII, 55-165.<br>See also American Revolution below.<br>Clive (1725-1774), VII, 59-65. | Werner and the "Neptunist" theory in geology, VI, 313.<br>Hutton and the "Vulcanist" theory in geology, VI, 312-334.<br>Joseph Black (1728-1754), VI, 272-278.<br>The discovery of "fixed air" (carbonic acid gas), 1753, VI, 272-278.<br>Latent heat, VI, 272.<br>James Watt (1736-1819), VI, 305-312. Applied the principle of latent heat to |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | from experience, the form from the mind. Space and time and the categories are mental forms. We can know only phenomena, not things in themselves, and only phenomena are bound by the natural laws we know. God and the Soul are things in themselves, not so bound, but free.<br>Biography, VI, 201.<br>Place in philosophy, VI, 40.<br>The Prolegomena, VI, 203.<br>Critique of Pure Reason, VI, 207-239. | Conquest of India.<br>On His Conduct in India.<br>American Revolution, VII, 166-245.<br>See also English Colonial System above.<br>James Otis and the Writs of Assistance (1761), VII, 167, 172-177.<br>The Rights of the British Colonies (1764), VII, 177, 178. | the steam engine and invented the separate condenser.<br>Priestley (1733-1804), VI, 278-283.<br>The discovery of oxygen.<br>Scheele (1742-1786), VI, 284-290.<br>Discovery of oxygen.<br>Cavendish (1731-1810), VI, 290-297.<br>The composition of water.<br>James Hargreaves, The Spinning Jenny, 1767, IX, 421. |
| | | Samuel Adams, (1722-1803).<br>Vindication of Boston (1764), VII, 178-9.<br>Against the Stamp Act.<br>Patrick Henry (1736-1799). Virginia Resolution against the Stamp Act (1765), VII, 179-184.<br>Franklin examined on the effect of the Stamp Tax (1766), VII, 185-198.<br>Chatham (1708-1778). Against the right to tax America (1766), VII, 65-77. | Lavoisier (1743-1794), VI, 297-305.<br>The Permanence of Matter.<br>The Nature of Combustion.<br>Respiration a Combustion.<br>Lavoisier overthrew the phlogiston theory and begun scientific chemistry. |
| | | Grenville (1712-1770). Answer to Chatham and against repeal of Stamp Tax (1766), VII, 70-72. | William Herschel (1738-1822), VI, 335-349.<br>Discovery of Uranus (1781), VI, 335-337.<br>Nebulous stars, VI, 337-347. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | | Mansfield (1705-1793). In favor of the Right to Tax America (1766), VII, 77-86. | Discovered two of the satellites of Uranus, two more of Saturn, and binary stars revolving around a common center, VI, 335. |
| | | John Dickinson (1732-1808). Against the suspension of the New York Legislature and internal taxation. Letters of a Pennsylvania Farmer (1767), VII, 199-208. | That the whole solar system is rushing toward the constellation of Hercules, VI, 347-349. |
| | | Edmund Burke (1729-1797). On Conciliation with America, VII, 87-117. | |
| | | Thomas Paine (1737-1809). Common Sense (1776), VII, 209-229. | Laplace (1749-1827), VI, 349-358. Worked out the movements of the solar system in detail. |
| | | Thomas Jefferson (1743-1826). A Summary View of the Rights of British America (1774), VII, 230-235. | The Nebular Hypothesis, VI, 350-358. |
| | | The passing of the Declaration and the arguments used for and against it, VII, 235-241. | Edmund Cartwright, The Weaving Loom, 1785, IX, 421. Lionel Lukin, The Life Boat, 1785, IX, 422. |
| | | John Adams (1736-1826). On the Declaration of Independence, VII, 243. | Montgolfier, Balloons, 1783, IX, 422. |
| | | Adam Smith (1723-1790. The Principle of the Commercial or Mercantile system, VI, 399-427. Free Trade and the Colonies, VII, 117-165. | Galvani (1790), noted that electricity contracted the muscles of a frog's legs, VI, 358. |
| | | Debates on the Federal Constitution, 1787, VII, 246-367. Those who attended were: | Volta (1745-1774). Invented the voltaic battery (1800), VI, 358-361. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | | **Virginia:** Geo. Washington, Edmund Randolph, James Madison, John Blair, Geo. Mason, Geo, Wythe, James McClurg. <br> **Massachusetts:** Elbridge Gerry, Rufus King, Caleb Strong, Nathaniel Gorham. <br> **Pennsylvania:** Benjamin Franklin, Robert Morris, Gouverneur Morris, James Wilson, Jared Ingersoll, Thos. Mifflin, Thos. Fitzsimons, Geo. Clymer. <br> **New York:** Alexander Hamilton, Robert Yates, John Lansing. <br> **Maryland:** Luther Martin, James McHenry, Daniel Carroll, Daniel of St. Thos. Jenifer, John Francis Mercer. <br> **North Carolina:** Alexander Martin, Wm. Richardson Davie, Wm. Blount, Richard Dobbs Spaight, Hugh Williamson. <br> **South Carolina:** John Rutledge, Chas. Cotesworth Pinckney, Chas. Pinckney, Pierce Butler. | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | | Connecticut:<br>Roger Sherman, Oliver Ellsworth, Wm. Samuel Johnson.<br>New Jersey:<br>William Patterson, William Livingston, David Brearly, Jonathan Dayton.<br>Delaware:<br>John Dickinson, Geo. Read, Gunning Bedford, Richard Bassett, Jacob Broom.<br>Georgia:<br>William Few, Abraham Baldwin, William Pierce, William Houston.<br>New Hampshire:<br>John Langdon, Nicholas Gilman.<br><br>The French Revolution.<br>Montesquieu (1689-1755).<br>The Separation of Powers, VII, 35-46.<br>The Physiocrats.<br>Quesnay (1694-1774).<br>General Maxims, VI, 392-399.<br>Rousseau (1712-1778).<br>The Social Contract, VII, 47-55.<br>Louis XVI. came to throne (1774), VII, 369.<br>Turgot (1727-1781). | |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | | Plans on accepting office, VII, 369, 390-394.<br>Necker and Calonne, VII, 370.<br>Arthur Young (1741-1820).<br>The Condition of the French People, VII, 374-390.<br>Sièyes (1748-1836).<br>"What is the Third Estate?", VII, 394-398.<br>States General (1789), VII, 370.<br>National Assembly (June 17, 1789), VII, 371.<br>Complaints of the People, VII, 398-411.<br>Capture of the Bastile (July 14, 1789), VII, 371.<br>Abolition of Feudal Privileges (Aug. 11), VII, 371, 411-414.<br>Declaration of the Rights of Man, VII, 415-417.<br>Origin of the Jacobins, VII, 428-430.<br>Mirabeau.<br>The Condition of Affairs (Oct. 15, 1789), VII, 417-428.<br>Danton, Marat, and Robespierre, VII, 372-373.<br>The Republic (Sept. 21, 1792). VII, 372.<br>Execution of the King, Jan. 21, 1793, VII, 372.<br>General War against Republic, VII, 373. | |

| RELIGION | PHILOSOPHY | SOCIAL SCIENCES | NATURAL SCIENCES |
|---|---|---|---|
| | Fichte (1762-1814).<br>Idealism, VIII, 318.<br>Doctrine of Knowledge, VIII, 319-330.<br><br>T. B. Malthus (1766-1834).<br>Principle of Population, VIII, 293-305. | Reign of Terror, VII, 373.<br>Robespierre supreme, VII, 373.<br>Worship of Divine Being Reestablished VII, 373.<br>Napoleon, VII, 373.<br><br>Benjamin Franklin.<br>Information to Those about to Emigrate to America, VIII, 5.<br>W. Winterbotham.<br>Conditions in the United States, VIII, 15.<br>T. B. Malthus (1766-1834).<br>Essay on the Principle of Population (1798), VIII, 293-305.<br>The Development of Political Ideas in the United States, 1789-1833.<br>Alexander Hamilton, VIII, 30-96.<br>The Powers of the Supreme Court, VIII, 31.<br>Monetary Measures, VIII, 30.<br>Discussion of a Protective Policy, VIII, 37-96.<br>Ideas of State Sovereignty, VIII, 96.<br>The Kentucky Resolutions (Jefferson), 1798, VIII, 97.<br>The Virginia Resolutions (Madison), 1798, VIII, 103.<br>The Kentucky Resolutions of 1799, VIII, 106. | Eli Whitney, The Cotton Gin, 1793, IX, 422.<br>Wm. Murdock. Gas Lighting, 1792, IX, 422.<br>Aloys Senefelder, Lithography, 1796, IX, 422.<br>Edward Jenner (1749-1823).<br>Theory of Small Pox Vaccination, 1798, VIII, 404-412.<br>Bichat (1771-1802).<br>The Doctrine of Tissues, VIII, 396-404.<br>Count Rumford (1753-1814).<br>The Nature of Heat, VIII, 435-441.<br>Thomas Young (1773-1829).<br>On the Interference of Light Waves, VIII, 442. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
| --- | --- | --- | --- |
| | Schelling (1775-1854), VIII, 330.<br>Hegel (1770-1831), VIII, 330.<br>The Universe the Realization of the World Spirit.<br>The Development of Spirit, VIII, 330. | Expansion, VIII, 108.<br>The Louisiana Treaty, 1803, VIII, 109.<br>Jefferson on the Louisiana Purchase, VIII, 112.<br>Marshall on the Constitutionality of Expansion, VIII, 118. | John Dalton (1766-1844), VIII, 368.<br>The Atomic Theory (about 1801-1804),<br>On the Constitution of Bodies, VIII, 368.<br>On Chemical Synthesis, VIII, 370.<br>Gay-Lussac (1778-1850), VIII, 375.<br>On the Combination of Gaseous Substances with each other (Law of Multiple Proportions), 1808, VIII, 375. |
| | | Northern Tendencies toward Secession, VIII, 121.<br>Josiah Quincy, VIII, 122.<br>Against the Admission of Louisiana, 1811, VIII, 122.<br>The Hartford Convention, 1814, VIII, 134. | Humphry Davy (1778-1829), VIII, 361.<br>Discovery of alkalies by electrolysis, VIII, 362.<br>The Safety Lamp, VIII, 361; IX, 424.<br>Forsyth, Percussion Arms, 1807, IX, 423.<br>Fulton, Steamboat, 1807, IX, 424. |
| | David Ricardo (1772-1823).<br>Theory of Rent, VIII, 305. | David Ricardo (1772-1823).<br>Theory of Rent, VIII, 305-316. | Lamarck (1744-1829).<br>Evolution by "Use," VIII, 412-418. |
| | Schopenhauer (1788-1860), VIII, 337.<br>Kant's thing-in-itself is natural will.<br>The Will in Nature, VIII, 338. | Henry Clay (1777-1852).<br>The "American Policy" of Internal Improvement, VIII, 148-160.<br>The Compromise of 1820, VIII, 148.<br>(See also on the Compromises of 1833 and 1850).<br>James Monroe (1758-1831).<br>The Monroe Doctrine, 1823, VIII, 288.<br>John Marshall (1755-1835).<br>The Supreme Court Superior to State Legislatures, VIII, 161. | Avogadro (1776-1865).<br>Law of equality of molecules, VIII, 384-389.<br>Dulong and Petit, VIII, 384.<br>Relation of specific heat and atomic weights (1813).<br>Stephenson, The Locomotive, 1814, IX, 424-426.<br>Cuvier (1769-1832), VIII, 418.<br>Believed in the Permanence of Species.<br>The Mutual Relations of Organized Beings, VIII, 419-424. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | Auguste Comte (1798-1857), VIII, 344.<br>Time at hand for a "positive" philosophy.<br>The Positive Philosophy, VIII, 345. | National Law Superior to Sate Law and the Doctrine of Implied Powers, VIII, 163.<br>The Supreme Court the Final Judge of the Construction of the Constitution, VIII, 186.<br>Thomas Benton (1782-1858), VIII, 196.<br>The Revision of the Tariff in 1828 and the Rise of the Doctrine of Nullification (Including selections from Rowan, Webster, Benton, Hayne and McDuffie), VIII, 197.<br>John Calhoun (1782-1850).<br>Address on the Relation of the State and the General Government, 1831, VIII, 211-236.<br>(See also on Texas and Slavery, Vol. IX.)<br>Robert Hayne (1791-1840).<br>The Doctrine of Nullification, VIII, 237.<br>Daniel Webster (1782-1852), VIII, 246.<br>The Supreme Court the Final Arbiter, VIII, 247.<br>The Nullification Ordinance, 1832, VIII, 270.<br>Andrew Jackson (1767-1845), VIII, 274.<br>Proclamation against Nullification, VIII, 275.<br>Henry Clay (see above).<br>The Compromise of 1833, VIII, 285. | St. Hilaire (1772-1844).<br>Unity of plan in animals, VIII, 395.<br>Von Baer<br>Development of the embryo (1828), VIII 394.<br>Faraday (1791-1867).<br>Liquefication of Chlorine, 1823, VIII, 390.<br>Sir Charles Bell (1774-1842).<br>The Relation between Motor and Sensory Nerves.<br>On the Nervous Circle, VIII, 425. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | | Pestalozzi (1746-1827).<br>The School at Bonnal, IX, 21-42.<br>Froebel (1782-1852).<br>The Kindergarten, IX, 402-410.<br>Horace Mann (1796-1859).<br>Lessons from Europe, IX, 410.<br>Political Ideas in the United States, 1833-1860, IX, 42.<br>Basil Hall (1788-1844).<br>Slave Conditions (1828), IX, 46-62.<br>Harriet Martineau (1802-1876).<br>Morals of Slavery (1835), IX, 63-83.<br>Geo. McDuffie (1788-1851).<br>The Rights of Slavery, IX, 83.<br>William Lloyd Garrison (1805-1879).<br>The Liberator (1831), IX, 95.<br>The Constitution a "Covenant with Death and an Agreement with Hell" (1842), IX, 97.<br>No Union with Slaveholders (1842), IX, 98. | John Walker, Friction Matches, 1827, IX, 426.<br>Oersted.<br>Identity of Electricity and Magnetism, IX, 5.<br>Ampere.<br>Electrical Laws, VIII, 430.<br>Daguerre and Niepce, Photography, 1814-1839, IX, 426.<br>Joseph Henry, IX, 10.<br>Electricity and Magnetism, IX, 11.<br>Faraday.<br>Electricity from Magnetism, IX, 17-21.<br>Charles Lyell (1797-1875).<br>Uniformity in the past changes of the earth, IX, 214-233. |
| | | In Defence of the American Anti-Slavery Society (1844), IX, 99-104.<br>Wendell Phillips (1811-1884).<br>The Murder of Lovejoy, IX, 105.<br>John Calhoun.<br>Texas and Slavery (1844), IX, 111.<br>Henry Clay,<br>The Compromise of 1850, IX, 117. | Theodor Schwann (1810-1882).<br>Cell Theory (1839), IX, 233-259.<br>Braconnet, Guncotton, 1832, IX, 427.<br>Morse, Telegraph, 1835, IX, 426.<br>Hussey and McCormick, The Reaper, 1831-33, IX, 428.<br>Morton, Anaesthetics, 1846, IX, 428.<br>Meyer, Colding, and Joule: |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | Conservation of Energy, 1847. | William Henry Seward (1801-1872).<br>The Higher Law (1849-50), IX, 123-132.<br>Stephen A. Douglas (1813-1861).<br>"Squatter Sovereignty" (1854), IX, 132.<br>Appeal of the Independent Democrats, Chase, Sumner, Giddings, etc. (1854), IX, 144.<br>The Republican Party, IX, 144.<br>Chief Justice Taney (1777-1864).<br>The Dred Scott Decision (1858), IX, 153. | Hermann Helmholtz (1821-1894).<br>The Conservation of Energy (1847), IX, 360-389. |
| | | Abraham Lincoln (1809-1865).<br>Against Squatter Sovereignty and the Dred Scott Decision (1858), IX, 177. | Herbert Spencer.<br>Progress: Its Law and Cause (1857), IX, 259-300. |
| | Evolution, 1858. | Jefferson Davis.<br>The Senate Resolutions, IX, 196.<br>The Platforms of 1860, IX, 199.<br>Douglas Democratic.<br>Southern Democratic.<br>Republican.<br>Constitutional Union.<br>Secession, IX, 208.<br>Ordinance.<br>South Carolina's Statement of the Case.<br>Guilds and Trade Unions, X, 6, 8, 19, 36, 46.<br>Monopolies and the Control of Trade, X, 6, 8, 9, 44, 52, 76, 101.<br>Karl Marx, X, 10-30.<br>Manifesto of the Communist Party.<br>Doctrine of Surplus Value.<br>Frederick Engels, X, 31-52.<br>Scientific Socialism. | Charles Darwin (1809-1882).<br>Natural Selection (1858), IX, 300-344.<br>A. R. Wallace.<br>Natural Selection, IX, 300.<br>Ernest Haeckel.<br>Fundamental Law of the Evolution of Organisms (1866), IX, 344-360.<br>Kirchloff and Bunsen.<br>Spectrum Analysis (1860), IX, 389-400.<br>Inventions, IX, 420.<br>Dynamo and Motor, IX, 428.<br>Bessemer Steel, IX, 429.<br>Typewriter, IX, 430.<br>Telephone, IX, 430.<br>Phonograph, IX, 431.<br>Electric Lights, IX, 431. |

| Religion | Philosophy | Social Sciences | Natural Sciences |
|---|---|---|---|
| | | Interstate Commerce Commission. The Control of Railroads (1887), X, 52-76.<br>Municipal Government.<br>Modern Systems Devised, X, 76-98.<br>Henry George.<br>The Single Tax, X, 98-114.<br>Education, X, 145-207.<br>Archæology: New light on Ancient Civilization, X, 241-266. | Ferrier, X, 396-417.<br>The Localization of Functions in the Brain.<br>Weismann, X, 343, 344-367.<br>Theory of Heredity.<br>Pasteur, X, 378-395.<br>Fermentation.<br>Inoculation for Hydrophobia.<br>Koch, X, 368-378.<br>Theory of Bacteria.<br>Mendeleef, X, 313-329.<br>The Periodic Law.<br>Lockyer, X, 329-342.<br>Chemistry of the Stars.<br>Loeb.<br>Influence of the ion on life, X, 313.<br>Kelvin.<br>Hypothesis of the atom, X, 313.<br>Maxwell, James Clerk, X, 267-273, 274-278.<br>Electricity and light vibrations in the ether.<br>Hertz, Electric waves, 274, 279-285.<br>Marconi and Preece, X, 302-311.<br>Wireless Telegraphy.<br>Röntgen, X, 286-301.<br>The X-Rays.<br>Crookes, X, 417-425.<br>Telepathy.<br>Langley, X, 208.<br>Aerial Navigation.<br>Diesel, X, 226.<br>Hersey, X, 219.<br>McCracken, X, 231.<br>Still, X, 234. |

## ADDENDA.

In volume 1 are found the following additions which are not included in the indices.

# GENERAL INDEX

## ALPHABETICAL AND ANALYTICAL

THE GENERAL ARRANGEMENT of this index is alphabetical, but the sub-heads under subjects are in chronological order to give a better view of the development of the subject.

## A



## B

## C

C



C

E



E

E

## G



## G

G



G

G



G

## G

## H



## H



## I

## L



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P



P

## P

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## R

S

T



U



V



W



W

LC

1

**ALDERMAN**
return * this b